the Petroleum Engineer

FOR MANAGEMENT

Directory of Instruments and Control Equipment for Petroleum Industry

Wanted: Scientists — Engineers

Electronics in Action

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

TRET-O-LITE

oil-field chemicals and services

DEMULSIFYING

Tret-O-lite assures a fast "break"; delivers low cuts. Rigid manufacturing controls assure continuing uniformity, consistent high quality. There is no better service.

CORROSION PREVENTING

Kontol Corrosion Preventive protects pumps, casing, tubing and sucker rods from attack by corrosive agents. Kontol long has been recognized as the leading organic corrosion preventive.

SCALE PREVENTING

S. P. Scale Preventive stops the formation of scale-forming inorganic solids. It keeps line-flow unrestricted, and prevents frequent shut-downs due to scaling.

PARAFFIN REMOVING

Solvo Paraffin Remover prevents the accumulation of line-plugging paraffins and asphaltines. It's much more economical to prevent paraffin accumulation with Solvo, than it is to shut down and clean out.

PRODUCTION STIMULATING

Mud-ex removes water, mud or emulsion blocks which curtain flow of oil from producing formations. It prevents the swelling of Bentonite clays and is effective for pressure treating and formation fracturing.

For complete information, ask your Tretolite Service Engineer.

TRETOLITE COMPANY

A DIVISION OF PETROLITE CORPORATION

5515 Telegraph Road, Los Angeles 22, California

369 Marshall Avenue, Saint Louis 19, Missouri

APC-56-14

Contents Pages 2-3 • Ad Index Page 6

SEPTEMBER 1956 One Dollar A Copy

	SERVICE	WHAT IT CONTAINS	FOR THESE WELLS	ADDITIONAL DESCRIPTION
OIL BASE	**PETROJEL**	Thickened crude, kerosene, or diesel fuel. Sand.	Oil or gas.	Primarily for use in formations with low acid solubility. Friction loss is lower than that of refined frac oils. Controlled fluid loss. Can be used at temperatures up to 200°F.
	PETROFRAC	Thickened crude, diesel fuel, or distillate. Sand.	Oil or gas.	Especially useful for treating wells with low bottomhole pressure. Use of high-gravity crudes makes it possible to fracture gas wells where heavier oil mixtures might be undesirable.
	SANDFRAC	Crude or refined oil. Sand.	Oil or gas.	For all types of formations—particularly suited to those of low acid solubility. Low fluid loss. Demulsifying agents may be added.
ACID BASE	**ACID PETROFRAC**	Acid-in-oil emulsion—using crude, kerosene, distillate, or diesel fuel. Acid is 90-95% of total volume. Sand.	Oil or gas.	Primarily for use in acid-soluble formations. Silicate control; retarded acid action; controlled fluid loss. Acid concentration can be varied from 1 to 15%.
	FRAC ACID	Thickened acid. Sand.	Oil, gas or water.	Primarily for use in acid-soluble formations where fracturing and acidizing are both desirable.
	STRATAFRAC	Acid-kerosene emulsion. Sand.	Oil or gas.	Primarily for use in acid-soluble formations. Acid concentration can be varied.
WATER BASE	**RIVERFRAC**	Fresh or salt water. With or without sand.	Oil, gas; water injection, disposal and supply.	For all types of formations. The use of water practically eliminates the fire hazard.
	WATERFRAC	Thickened fresh or salt water. Sand.	Oil, gas; water injection, disposal or supply.	Primarily for use in formations in which the use of oil-base treating materials might be undesirable or detrimental.

8 basic ways Dowell fractures wells

each treatment is selected and tailored to fit your well

Widest variety of fracturing services and materials in the oil industry

F.L.A.—Added to the treating fluid, this easy-to-use powder substantially lowers the fluid-loss characteristics.

FIXAFRAC—A Dowell service that temporarily seals initial fractures, or permeability already present, to permit a concentrated fracturing or acidizing attack on other sections of the pay formation.

MUD ACID—A Dowell acid that dissolves clay minerals and destroys the swelling properties of bentonitic material. As a spearhead, it increases treating effectiveness by cleaning formation face.

ACID INHIBITORS—Dowell acid inhibitors provide maximum protection to metal up to 350°F., yet allow full treatment effectiveness.

ADDITION AGENTS — Dowell engineers use a wide variety of addition agents in tailoring fracturing treatments to fit your wells. These agents control swelling of clay minerals and other silicates, lower surface tension, minimize formation of emulsions, speed up or retard reaction rate of acids with dolomites, etc.

HIGH INJECTION RATE—Special-built Dowell equipment provides better distribution of sand and treating fluid. More of pay zone is treated. Results have shown more production and slower decline.

MODERN EQUIPMENT — Typical of the Dowell look to the future is the development of the rugged Allison-powered pumping unit with its 1500-h.p. aircraft engine. The Allison, the new 60-barrel-per-minute blender and the revolutionary Remote Control Panel bring new power and safety to fracturing and acidizing.

In the field, in treatment after treatment, this rugged Dowell pumper has proved its dependablity in oil and gas wells.

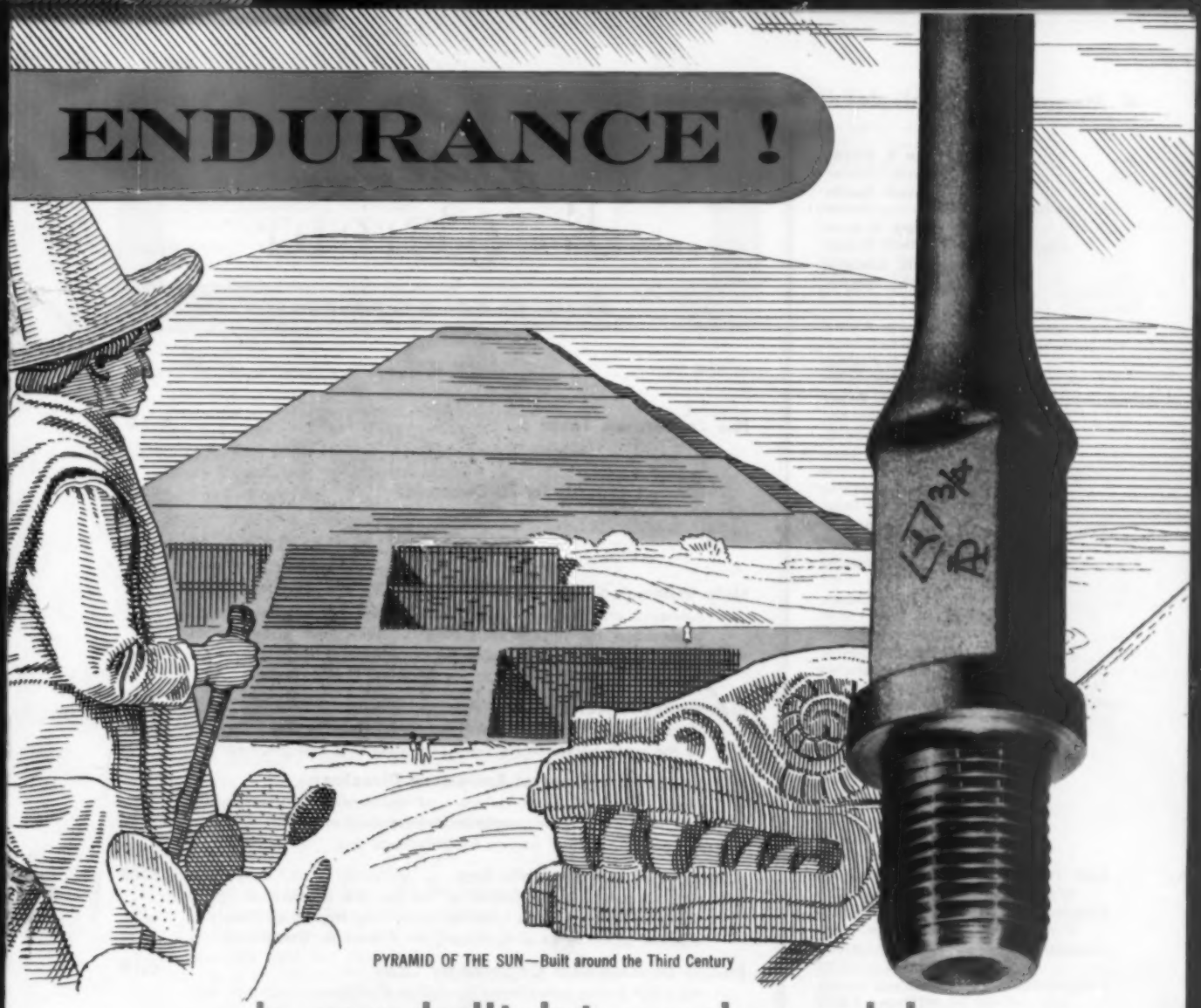
For more information, or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. I-12.

services for the oil industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

ENDURANCE !



PYRAMID OF THE SUN—Built around the Third Century

. . . is now built into sucker rods!

THE DEEPER you have to go to get production, the more you should know about the remarkable properties of a special new steel which United States Steel research engineers have developed.

After extensive laboratory tests, a special combination of alloying elements, including boron, was found to produce a steel of exceptional toughness and strength when the complete heat treatment with LIQUID QUENCHING and tempering was employed. Steel with greater resistance to fatigue was thus made available to industry.

While researchers were exploring its unique properties in numerous other fields, "Oilwell" produced several strings of sucker rods from this tough-strong steel to conduct a number of field tests. The following one is typical:

In April, 1952, three strings were run below 6,900 feet by Sohio Petroleum Company in the West Edmond Field near Edmond, Oklahoma. Loading varied from 25,000 to 30,000 pounds per square inch. Approximately four years later *all three strings* are still in operation.

The fatigue-resistant properties of this new steel have been fully utilized and stabilized with "Oilwell's" modern and complete heat treating facilities, and sucker rods of this new steel are now on *regular production*. They are known as Grade "Y" rods, and numerous companies are specifying them for deep wells where they are proving far superior to anything previously used. They work longer under heavy loads without failure.

Why not try a string of Grade "Y" sucker rods in your next heavy well? You'll be well pleased with their price! We welcome mixed-string tests with more expensive, so-called "high strength" rods.

OIL WELL SUPPLY
DIVISION
UNITED STATES STEEL CORPORATION

Executive Offices—DALLAS, TEXAS
Export Office—
30 ROCKEFELLER PLAZA
NEW YORK 20, N. Y.

Area Offices—
CALGARY, ALBERTA
CASPER, WYOMING.....COLUMBUS, O.
DALLAS, TEXAS.....HOUSTON, TEXAS
TULSA, OKLA.....LOS ANGELES, CALIF.

Branches Serving All Oil Fields

USS "OILWELL" TRADE MARK

UNITED STATES STEEL

A Magazine of Petroleum Management

the Petroleum Engineer

FOR MANAGEMENT

NUMBER 10 VOLUME XXVIII SEPTEMBER, 1956

The Conference Table A-10

Highways and Tax Ways

Earnings 18% Up for 70 Companies

E SECTION FOLLOWS A

Help Wanted: Scientists, Engineers E-3
Amazing progress in industry and business has created such a demand for higher technological skills that shortage of trained manpower is threatening to bottleneck further advance. Here are some of the facts. — *Dr. Alan T. Waterman*

Electronics in Action E-5
Electronic computers are proving their worth in Cities Service as the work horses in the field of accounting and engineering.

Instruments and Control Equipment Directory E-8
More than 100 manufacturers of automation machinery for the petroleum industry and each item they make are listed in the second annual survey for reference use.

A New Way to Dehydrate Gas E-13
Once again they've found a use for the proverbial "pig's squeal." Putting waste brine to work, they tripled efficiency of calcium chloride as a desiccant. — *Robert A. Daugherty*

Italian Development Crippled by Laws E-19
New bill being considered by Italian Parliament may not help operations, but they could not be much worse than present ones that go back 60 years. . . . Sicily offers remarkable contrast. — *Fernando de Mattia*

You Need Leaderscope E-22
How do you choose an executive? Do you want a leader? Or one who goes along with the bosses? The author, a management consultant, takes a whack at "committee" management and the "committeemen" hired for executives. — *E. A. Butler*

How to Treat the Old Girl E-24
The secretary who does your letters can do a better job if you give her half a chance . . . it will cut costs, too. — *John Rasco*

Education via Grants E-25
This is another of a series showing methods used by petroleum companies to contribute to higher learning.

DRILLING AND PRODUCING

Horizons Unlimited in Well Workovers B-21
Don Taylor

The Men Behind This Special Workover Issue B-22

An Approach to Analyzing Ailing Wells B-24
Raoul Bethancourt

The Analysis of Problem Wells B-30
Norman J. Clark and W. P. Schultz

Joe B. Weeds
President and Publisher
Abbott Sparks
Vice President and Advertising Director
Frank H. Love
Vice President and Editorial Director
L. H. Johnston
Secretary-Treasurer

•

Ernestine Adams
Management Editor
J. E. Kastrop
Editor, Drilling, Producing, and Exploration
Arch L. Foster
Editor, Refining, Petrochemical and Gas Processing
Frank H. Love
Editor, Oil, Gas, and Products Pipelining
James A. LeVelle
Engineering Editor
Dean Hale
Technical Editor
C. R. Graham
Field Editor
Jerry Stumm
Editor, Pacific Coast, RYan 1-5024
1011 S. Madison, Pasadena 5, California
Donald M. Taylor
Editor, Gulf Coast, JAckson 3-6346
2370 Rice Blvd., Room 110, Houston, Texas
Bette Ruth Horton
Editorial Assistant
Jan Gartman
Editorial Assistant
Donald D. Fickert
Presentation Editor

•

Ed Sealey
Advertising Service Manager
NEW YORK— John Wallace
52 Vanderbilt Ave., MUrray Hill 6-7232
CHICAGO— E. V. Perkins
53 West Jackson Blvd., HArrison 7-6883
PASADENA— Richard P. McKey
465 East Union, RYan 1-8779
PITTSBURGH— William Faville
4525 McKnight Rd., WEllington 1-0619
HOUSTON— Roger Motheral
2370 Rice Blvd., Room 110, JAckson 3-6346
DALLAS— Jess Adkins
800 Davis Building, STerling 4404
John McDonald
Special Representative

•

Charles McKean
Circulation Director
Royal Courtney
Circulation Manager
Morris Hodges
Production Manager
Bobbie Robinson
Assistant Production Manager

Copyright 1956

The Petroleum Engineer Publishing Company
Indexed by Industrial Arts Index and The Engineering Index, Inc.
Member of Audit Bureau of Circulation and Associated Business Papers

The Petroleum Engineer for Management, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the Petroleum Industry, United States, Canada, and Foreign, $6.00 per year; $10.00 for 2 years; $13.00 for 3 years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879.

Permanent Type Completions and Wireline Workovers B-39
Gilbert H. Tausch and Price McDonald

Well Stimulation by Fracturing B-53
M. J. Kaufman

Ship That Moves Sideways B-68

Planning and Supervising Workover Jobs B-73
J. N. Pedersen

Parallel Strings and Pumps Run in 5½-in. Casing B-85
Thomas C. Aitken

Evaluation of Workovers . . . Before and After B-97
J. J. Arps

Workover Problems and Their Solutions B-107
C. J. Rodgers

Unusual Methods Pay Off — Sometimes B-129
T. J. McIntyre

Safe Practices in Workover Operations B-134b
Don A. Klemme

Unique Tools and Methods Used in Gas Well Workovers . . . B-140
Sidney S. Galpin and Palmer H. Montgomery

Multiple Zone Workovers B-156
Royal W. Reiss

REFINING AND PETROCHEMICAL

Taming Wild Waste Water C-3
Gordon W. Brown and James E. Sublett

Hydraulic Drive for Aerial Cooler Fans C-8
D. E. Bumgardner

Oxygenated Petrochemicals C-11
Peter W. Sherwood

Automatic Tube System C-17
Carroll Hennessy

REFINING FUNDAMENTALS

Process Division: Petroleum Products — Nature and Properties, Chapter 12 . . . . . C-20
V. A. Kalichevsky

New Plant Construction — Planned and Underway C-24

REFINING IN BRIEF

Needed: A New Knock Yardstick? C-38
C. J. Domke, N. D. Esau, D. S. Gray and H. R. Taliaferro

Road Ratings With a Chassis Dynamometer C-42
P. E. Mizelle, J. C. Porter and A. R. Rescorla

Petrochemicals Look for New Instruments C-46
R. G. Marvin, W. L. Stuart, G. W. Lunsford and E. E. Ludwig

Road Ratings Obtained in a Single-Cylinder Engine C-50
E. M. Barber, H. I. Wilson and T. H. Randall

OIL AND GAS PIPELINING

Slurry Handling: New Frontier for Pipelining Operations D-16

Out West, Gilsonite Goes Over the Mountain D-18
Frank H. Love

Back East, Coal Commutes from Cadiz to Cleveland D-20
Dean Hale

Stanolind's Experiences Show VPC to Be Economical, Efficient, Simple D-25
G. O. Bates, J. E. English and G. M. Franklin

Ideas at Work in Pipelining D-30

The Blow Down D-32

Pipe Line Flow Calculations D-33
J. W. J. Bercher

How to Use Passive Repeaters D-39
R. H. Davis

Why Cooling Towers Decay — How To Prevent D-43
E. H. Hurst

Cathodic Protection Interference Problems — How to Solve Them . D-53
Francis W. Ringer

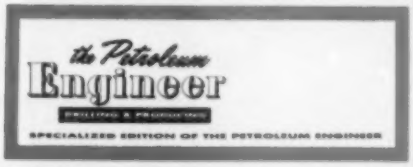
Beacons and Paint D-67
C. E. Upson

Preventing Fires While Repairing Lines D-82
W. J. Irwin

FEATURES

The Course of Oil A-4
The Bottleneck Is Mind-power
Advertisers' Index A-6
Petroleum Profile A-8
Paul G. Blazer
Highlights A-12
Meetings A-17
Laugh With Barney E-26
Women at Work E-29
General Personals E-30
Oil and Gas Trade News E-32
Trade Personals E-35
Books E-40
Of Things to Come in Oil B-3
Exploration Activities B-158
What's Doing in Drilling B-162
Running Tour With Men in the Industry B-166
New Drilling and Producing Equipment B-182
New Drilling and Producing Literature B-184
Refinery Plants Scheduled for Completion C-55
Refining and Petrochemical Personals C-58
The Petroleum Engineer's Continuous Tables C-66
New Refining Equipment C-67
New Refining Literature C-68
Pipe Line Developments D-3
Pipe Line Projects D-73
Pipe Line Personals D-78
With the Pipe Line Contractors D-80
The Petroleum Engineer's Continuous Tables D-88
New Pipe Line Equipment D-89
New Pipe Line Literature D-90

Four Editions
Published Monthly by
The Petroleum Engineer
Publishing Company
800 Davis Building
Dallas 2, Texas



THE BOTTLENECK IS MIND-POWER

When President Nasser of Egypt seized the Suez Canal men went to work with great computers to solve a world problem: If no oil tankers were allowed through the canal, how could Europe best be supplied? If Middle East oil, too, were seized, where would supplies come from?

The United States uses only a small amount of Middle East Oil, but Europe, growing more dependent daily on oil energy, had to be supplied or business would be paralyzed.

Where was extra production readily available? What distribution facilities could be used? Where were supplies stored? These were questions that had to be answered promptly and accurately. Computers were faster and more accurate than human beings.

Machines came to the rescue in the man-made muddle. Perhaps in the future a machine may compute the consequences of rash acts and deter even willful rulers.

Right now the bottleneck in the progress of automation is trained scientists, engineers, and technicians. In his article on Page E-3, Dr. Alan T. Waterman reports that one manufacturer needed 7500 mathematicians to man computers on order, of whom about 1500 should be Ph.D's. The hitch is that a total of only 250 Ph.D's in mathematics will be graduated this year in the United States.

The old reactionary cry that the machine throws men out of work is answered by the fact that machines now wait for people to be trained to run them. Automation is perhaps the greatest force, outside human ambition, in the upgrading of mind-power.

It works through all levels of business and industry. Management's problems are more extensive and more complex. Replacements and additions to management must be in training long before taking on executive duties. Plans must be made farther ahead than in earlier days. Employees on the automation front may find themselves in competition with computers unless they are willing to gain new knowledge so they can use machines as a tool.

The machine is doing well. But automation will have to rest awhile until mankind catches up or we must do an accelerated job of education and training.

Ernestine Adams.

"AUTOMATION WEEK"

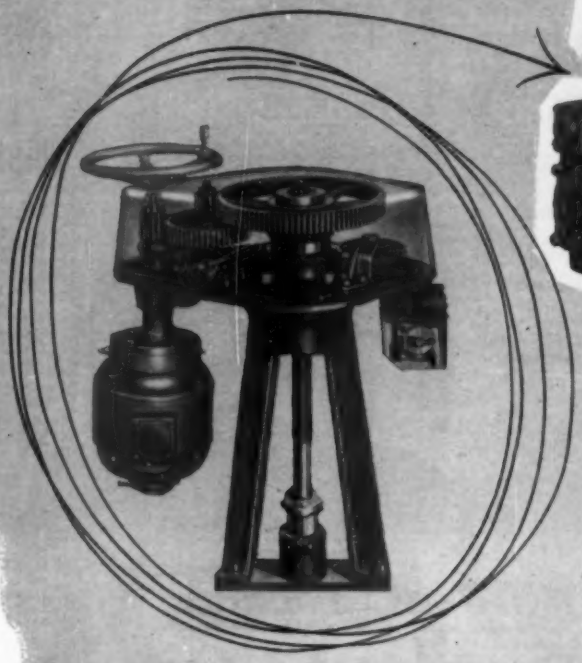
Mayor Wagner proclaimed the week of November 26-30 in New York as "Automation Week."

During the week the Third International Automation Exposition is scheduled and also conferences will be held on "Automation for the Office" and on "Human Engineering Automation."

Earlier — September 17-21, in New York, the 11th Annual Instrument-Automation Conference and Exhibit will be held.

It is for this conference particularly that THE PETROLEUM ENGINEER has continued its annual Directory of Instruments and Control Equipment for the Petroleum Industry (E-8). This gives you a handy reference when you want to find the manufacturers of a particular item to automate an operation in the oil or gas industry.

In the PINK of Condition



CHAPMAN MOTOR UNITS

We've done one thing for you. Chapman's Motor Units . . . for operation of valves, floorstands and sluice gates . . . are in the best of condition for accurate performance and longer, lower cost life.

We've made them as you like them . . . simplified them . . . streamlined them . . . taken off all the fat. In fact, when you look at a Chapman Motor Unit today, you can only find approximately *half as many parts* as on any other unit.

This simplicity, combined with Chapman's traditional ruggedness, means less trouble and lower maintenance over a longer period of smooth, accurate performance.

How can you go wrong? With Chapman Motor Units, the simplified design . . . the sturdy construction . . . mean no drift; less slash, accurate micrometer-controlled limit switch for predetermined seat tightness; quiet motor driven operation at all *times*. All at the lowest overall cost.

No trouble with operating positions. Operation is assured at any angle. Rugged stub-tooth gears need no grease or oil. No trouble with operating conditions. All units are weatherproof . . . *steam tight*. No trouble even with installations. When used with floorstands they are completely wired at the factory . . . ready to connect with your leads. Easy and simple to install.

Get our new catalog . . . Catalog 51 . . . on Chapman motor units today.

The Chapman Valve Manufacturing Co.
INDIAN ORCHARD, MASSACHUSETTS

ADVERTISERS' INDEX

A

Affiliated National Hotels E-24
Ajax Iron Works B-169
Alco Products, Inc. B-18
Allis-Chalmers, Buda Division B-152
Allis-Chalmers D-2, D-79, D-86-D-87
Alten Foundry & Machine Works, Inc. B-180
American Meter Company A-20-A-21
American Recording Chart Co. E-26
Ampco Metal, Inc. B-86, B-158, C-52, C-60, C-62
Anderson, V. D., Company, The E-49
Armco Drainage & Metal Products, Inc. D-4
Axelson Manufacturing Company B-5-B-8

B

B and W Inc. B-160
Babcock & Wilcox Company, The C-39
Baker Oil Tools, Inc. B-20, B-56-B-57
Baldwin-Lima-Hamilton Corporation C-54
Baroid Division, National Lead Company B-69-B-72
Barrett Division, Allied Chemical & Dye Corporation D-1
Beaird, J. B., Company, Inc., The E-27
Berry Division, Oliver Iron & Steel Corporation B-164
Bethlehem Steel Company E-48
Bethlehem Supply Company B-113
Brakesol, Inc. E-34
Broderick & Bascom B-116
Brown Oil Tools, Inc. B-134
Bucyrus-Erie Company B-10
Byron Jackson Tools, Inc. B-15, B-137

C

Cable Engineering B-155
Campbell, J. A., Company D-75
Cardwell Manufacturing Company B-108-B-109
Caterpillar Tractor Co. E-2, E-15
Chapman Valve Manufacturing Co., The A-5
Chemical Process Co., The B-128
Cherokee Laboratories, Inc. B-101
Chicago Bridge & Iron Company E-1b
Christensen Diamond Products B-105
Cinch Pipeline Equipment, Inc. D-75
Cleveland Trencher Company, The D-70
Classified E-55
Climax Engine & Pump Mfg. Co. B-103
Colorado Fuel & Iron Corporation, The B-147, B-178
Continental Supply Company B-115-B-116, B-119, B-133, B-172-B-173, B-177
Cooper-Bessemer Corporation D-37
Core Laboratories, Inc. B-159
Crane Co. E-1f
Crose, M. J., Manufacturing Company, Inc. D-34
Crossett Chemical Co. B-139

D

D+B Division B-119, B-172-B-173
Davison Chemical Company, Division of W. R. Grace & Co. C-43
Diamond Chain Company, Inc. B-14
Dowell Incorporated Inside Front Cover, A-15
Dresser Industries, Inc. ..... B-2, B-84, B-143, B-144, B-151, Inside Back Cover, D-5
Dresser Manufacturing Division D-5
Drilling & Service B-59
Drilling Specialties Company B-37
DuPont, E. I., de Nemours & Company, Inc. C-35-C-36, C-45, C-61
Duraметallic Corporation E-24

E

Eastern Industries, Inc. E-53
Emerol Mfg. Co., Inc B-13
EMSCO Manufacturing Company B-119, B-133, B-172-B-173
Ernst Water Column & Gage Co. C-52, C-64
Ethyl Corporation C-4-C-5

F

First National Bank in Dallas E-43
Fisher Governor Company E-31
Floridin Company C-58
Fluor Corporation, Ltd., The E-1g
Fluid Packed Pump Company, ... B-93, B-125-B-126
Foxboro Company, The C-56-C-57
France Packing Co. E-39

G

Garrett Oil Tools B-141
Gaso Pump & Burner Mfg. Co. D-55
General American Transportation Corporation E-41
General Electric Company B-48-B-49, B-165, D-69
Gilbert & Barker Manufacturing Company D-7
Glitsch, Fritz W., & Son C-51
Gorman-Rupp Company, The A-18
Goslin-Birmingham Manufacturing Co., Inc. C-31
Grove Valve & Regulator Company D-45
Guiberson Corporation, The B-96
Gulf Oil Corporation E-42

H

H & L Tooth Company E-1a
H & M Pipe Beveling Machine Co. D-66
Halliburton Oil Well Cementing Company ..... Back Cover, B-63
Hammond Iron Works E-54
Harshaw Chemical Co., The C-59
Hercules Tool Company B-162
Hill, Hubbell & Company D-8
Hilliard Corporation, The E-33
Holcombe Company, Inc., The D-65
Homelite a Division of Textron, Inc. A-16-A-17
Hotel Pittsburgher E-49
Houston Oil Field Material Company, Inc., B-87
Hughes Tool Company B-11-B-12
Hutchison Calculator D-74
Hutchison Manufacturing Co. B-154
Hydril Company B-43

I

Ingalls Shipbuilding Corporation B-168
Ingersoll-Rand A-19
International Harvester Company E-50-E-51
International Nickel Company, Inc., The C-49
Irving Subway Grating Co., Inc. A-17

J

Jensen Bros. Mfg. Co., Inc. B-160
Jerguson Gage & Valve Company C-64
Jet-Lube, Inc. B-154
Johns-Manville D-85
Johnston Testers B-74-B-75
Jones & Laughlin Steel Corporation, Supply Division B-19

K

Kaiser Steel Corporation D-14
Kobe, Inc. B-65
Koppers Company, Inc. D-9, D-56, D-84
Kwik-Mix Company E-40

L

Lane Wells Company ..... Inside Back Cover, B-2
Larkin Packer Company, Inc. B-110-B-111
LeRoi Division of Westinghouse Air Brake Co. A-24
Levingston Shipbuilding Company B-92
Lone Star Cement Corporation B-41
Lone Star Steel Company B-155
Luber-Finer, Inc. B-168
Lufkin Foundry & Machine Company B-77
Lufkin Rule Company, The E-36
Lunkenheimer Company, The E-45

Mc

McCullough Tool Company B-167
McEvoy Company B-180

M

Madsen Works C-54
Magnet Cove Barium Corporation B-143
Maloney, F. H., Company D-10
Marsh, Jas. P., Corporation A-9
Martin-Decker Corp. B-154
Martin, John N., Manufacturer B-161
Mathey, C. A., Machine Works, Inc. B-153
Mercoid Corporation, The D-71
Minneapolis-Honeywell Regulator Co. D-11
Mission Manufacturing Company B-94-B-95
Moore, Lee C., Corporation B-138
Motorola Communications & Electronics, Inc. D-61

N

National Aluminate Corporation E-17
National Supply Company, The B-81-B-84
National Tank Company E-56
New York Belting & Packing Co. B-115
Nordberg Mfg. Co. D-81
Nordstrom Valves E-37-E-38

O

O T M Corporation E-28
Oakite Products, Inc. C-54
Oil Base, Inc. B-4
Oil Center Tool Co. B-1
Oil Well Supply Division A-1, A-7
Orbit Valve Company B-179
Otis Pressure Control, Inc. B-66-B-67, B-106

P

Pacific Pumps, Inc. B-151
Parsons Company D-57
Pasdral, Tod D-13
Peerless Manufacturing Co. A-13
Pelican Supply Co., Inc. D-68
Perforating Guns Atlas Corporation B-171
Permian Basin Oil Show E-23
Petro-Chem Development Co., Inc. E-44
Petreco E-47
Petroleum Electric Power Association C-2
Petroleum Equipment Suppliers Association B-60-B-61
Pipe Line Anode Corporation D-58
Pipeline Cleaners Co. D-68
Pittsburgh Coke & Chemical Co. D-51
Polyken Sales Division, The Kendall Company D-52
Powell Valves C-63
Pritchard, J. F., & Co. D-72-D-73
Procon Incorporated E-1d

R

Radio Corporation of America D-48-D-49, D-71
Rector Well Equipment Company, Inc. B-170
Reed Roller Bit Company B-88-B-89
Ridge Tool Company, The E-52
Rockford Clutch Division, Borg-Warner B-142
Roeblings, John A., Sons Corporation A-22
Roper, Geo. D., Corporation D-64
Rust-Oleum Corporation A-23

S

Salt Water Control, Inc. B-130-B-132
Schield-Bantam Co. D-62
Schlumberger Well Surveying Corporation B-98-B-99
Shaffer Tool Works B-90-B-91
Shell Oil Company E-46
Smith, A. O., Corporation D-76-D-77
Southwest Industries, Inc. B-121
Southwestern Industrial Electronics Co. B-144
Spang & Company B-146
Standard Pipeprotection, Inc. D-42
Stearns-Roger Mfg. Co., The C-37
Stitt Ignition Company E-34
Sun Shipbuilding & Dry Dock Company C-1

T

Tapecoat Company, The D-71
Technical Oil Tool Corporation B-123
Texas Company, The E-18
Thompson Tool Company E-29
Thornhill-Craver Co. B-79
Toledo Pipe Threading Machine Co., The E-49
Tretolite Company ..... Front Cover
Twin Disc Clutch Company B-176

U

Union Switch & Signal, Division of Westinghouse Air Brake Company E-1h
Unit Crane & Shovel Corporation B-135
United States Rubber Company C-65
United States Steel Corporation A-1, A-7, C-41
Universal Oil Products Company C-26-C-27, D-41

V

Visco Products Company, Incorporated E-1
Vogt, Henry Machine Co. C-47

W

W-K-M Manufacturing Company, Inc., a Subsidiary of A C F Industries Incorporated B-175
Walker, W. L., Co. D-80
Walworth Company E-1c
Waukesha Motor Company B-16
Welex Jet Services, Inc. B-17
Well Equipment Mfg. Corp. B-9
Western Company, The B-163
Western Supply Company C-53
Wheeling Machine Products Company E-16
Wilkinson Products Company D-68
Williams Pressure Service Company D-63
Williamson, T. D., Inc. D-60
Wilson Supply Company B-174
Worthington Corporation B-127, D-12
Wyatt Metal & Boiler Works E-1e

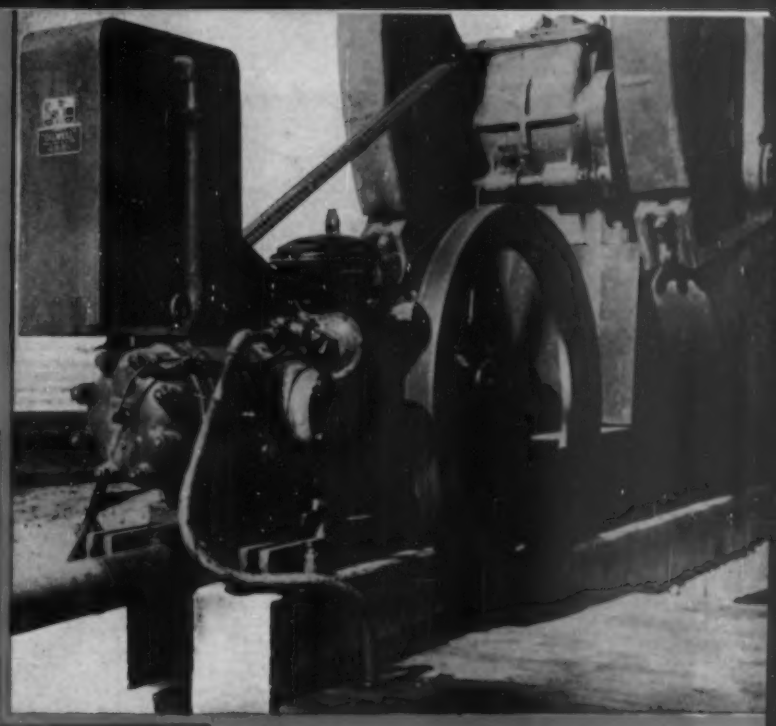
Y

Young Radiator Company E-52
Youngstown Sheet & Tube Company, The E-21

Z

Zachry, H. B., Co. D-15

In the 20-70 hp. range...



... ***"Oilwell" Specialists in Production Equipment Recommend***

Lorain Gas and Diesel Engines

for dependable low cost PUMPING Power

● Winter's cold or summer's heat does not impair the consistently good performance of these heavy-duty two-cycle pumping engines.

Their slow-speed design enables them to stay on the job for years without costly repairs and with very little attention.

BRIEF SPECIFICATIONS

	Type L	Type O	Type R	Type A
Bore and Stroke, in.....	7½ x 8	9½ x 10	12 x 13	13 x 13
Displacement, cu. in.....	353	708	1470	1725
Speed Range, rpm.....	300-600	250-500	200-350	200-350
Max. Piston Speed, ft.....	800	833	758	758
Rated Horsepower.....	14-25	24-42	35-59	37-70

Cylinder liner is of the wet type and can be replaced without special tools. Even when repairs are necessary, they can be made right on the lease, without the expense of trucking the engine to a shop.

Lorain engines, as well as maintenance supplies, are available at your nearest "Oilwell" store. Try one on your next heavy-duty pumping job and see for yourself how economical they are to operate.

OIL WELL SUPPLY
DIVISION
UNITED STATES STEEL CORPORATION

Executive Offices—DALLAS, TEXAS
Export Office—
30 ROCKEFELLER PLAZA
NEW YORK 20, N. Y.

Area Offices — CALGARY, CANADA
CASPER, WYOMING . . . COLUMBUS, O.
DALLAS, TEXAS . . . HOUSTON, TEXAS
TULSA, OKLA. . . . LOS ANGELES, CALIF.

Branches Serving All Oil Fields

USS "OILWELL" TRADE MARK

UNITED STATES STEEL

Petroleum Profile

PAUL G. BLAZER holds a position probably unique in the oil industry today. No company with its expanding sales and capital assets is so closely associated with one individual as is Ashland Oil and Refining Company with Paul Blazer.

Mr. Blazer helped organize Ashland and built it bit by bit to one of the foremost corporations in the industry. He forged it from new ideas and long hours of work and strengthened it by merging with or buying other companies — about 50 other firms, it is believed. Ashland is Paul Blazer's baby and a healthy, growing baby it is. Since World War II, Ashland sales have multiplied until in 1955 they are 13 times what they were 10 years ago. He proved that an independent refiner can serve and prosper.

This man who built a large oil company began his career at the ripe age of 15 in Aledo, Illinois. He'd worked even before that for his father, a weekly newspaper editor, but this was his own magazine subscription agency. Curtis Publishing Company (Saturday Evening Post) thought he was good enough to hire him as educational division representative. Paul worked at this job while putting himself through two years at William and Vashti College in Aledo and he went two years to the University of Chicago. He kept up his subscription business, played football and found time to court Georgia Monroe, whom he married in 1917.

Young Blazer — tall, handsome, popular — became advertising manager of Great Northern Refining Company, Chicago, and later helped organize Great Southern Refining Company, Lexington, Kentucky, in 1919. He was sales manager and vice president. In 1924 he was one of the incorporators of the Ashland, Kentucky, Refining Company, and became its president and general manager.

From that time on Blazer concentrated on one company. Many other firms were consolidated with Ashland and the corporation took on size and substance. In 1936 Swiss Oil and Ashland Refining merged and the present Ashland Oil and Refining Company was formed.

Ashland has widespread interests — venturing into Canada and the Middle East. The company owns 12.7 per cent of American Independent Oil Company, which has been successful in Kuwait Neutral Zone.

Besides the refinery at Ashland, there are plants at Canton, Findlay, and Niles, Ohio; Buffalo, New York; Freedom, Pennsylvania; and Clarksville, Indiana. Fourteen products terminals are scattered throughout the territory where Ashland products are sold. One lake tanker plies the Great Lakes and many tow boats and barges transport products to terminals along the Ohio River. Ashland is spending more than $21 million this year on capital expenditures.

PAUL G. BLAZER

Chairman of the Board

Ashland Oil and Refining Company

One thing for sure, Paul Blazer hasn't limited himself to building a business — he has helped to build his city, his state, and his country. He has worked for education, for better industry relations, for national defense. He is chairman of the board now but he is hardly less active. His nephew, Rex Blazer, is president.

His leadership has drawn many honors and he keeps paying for them with more valuable service. The University of Kentucky conferred upon Blazer the Sullivan Medallion Award in 1948 and the LL.D. degree in 1952. He received the LL.D. degree from Centre College in 1948 and in 1953 was elected trustee of that institution.

Mr. Blazer served on the Petroleum Industry War Council during World War II and was chairman of the District II Refining Committee for the Petroleum Administration for War. He is a member of the National Petroleum Council and a director of the American Petroleum Institute. He served as a member and later as chairman of the board of directors of the Cincinnati Branch of the Federal Reserve Bank of Cleveland.

At the 1956 annual meeting of the Newcomen Society, Paul Blazer was guest of honor and speaker. The Society honors corporate enterprises whose economic contributions have been notable. In his address "E Pluribus Unum" (One Out of Many) the Ashland chairman said, "It is my hope that this presentation . . . may call attention to *a method of industrial development* which is susceptible of wide application."

Perhaps the most significant honor of all the Blazer triumphs was being named "Kentuckian of the Year" in 1954 by the Kentucky Press Association.

As one newspaper reported, the fact that Blazer had built Ashland into one of Kentucky's biggest industries, employing 4300 people, was not enough to have won him the award. The knowing newspaper fraternity was convinced that Blazer is not only a good businessman but one who believes in public service and practices his belief.

MARSH

The world's finest pressure gauge

JAS. P. MARSH CORPORATION • SKOKIE, ILLINOIS

"THE STANDARD OF ACCURACY"

THE CONFERENCE TABLE

"Horse power was much safer when only the horses had it."

Science in Industry

"Perhaps the most characteristic phase of America's approach to economic advance is its intense application of science to the nation's productive effort," so says the booklet issued by Du Pont Company called "Science in Industry." It is one of the finest publications we have seen explaining simply and with excellent illustrations the six scientific principles and six inventions that reshaped civilization. Also shown in the booklet are six of the great monuments to science to the nation's productive effort," so says the booklet from Du Pont, Public Relations Department, Wilmington 98, Delaware.

Highways and Tax Ways

The signing of the new federal highway act was the first step toward the largest public works program in the history of this nation. The measure calls for $25 billion dollars in federal highway allocations during the next 13 years. States will be required to match these federal funds only on a 90-10 basis, which means that both will contribute $27.8 billion dollars during the period. This will be a fine thing for the country and it will be a great stimulus to the oil industry. First from the construction standpoint, the amount of motor fuels and lubricants needed to do the work will amount to a large volume. Materials used for the highways, such as asphalt, will be another industry expansion feature.

Overall sales of construction materials will be nearly $500 million in 1957 rising to $2.7 billion.

The money for the big program will come almost entirely from the petroleum industry. Below is a breakdown of anticipated revenues from new and existing federal excises to be used for the highways. The industry not only supplies the money for its own part in the highway project but for almost everything that is used.

TRUST FUND RECEIPTS
(In millions of dollars)

	From new taxes	*From existing taxes*	*Total*
Motor fuels	$ 9,546	$20,096	$29,642
Tires and tubes	2,089	3,588	5,677
Trucks and buses	957	1,356	2,313
Truck licenses	866	——	866
	$13,458	$25,040	$38,498

For Writing Out Loud

After you've read the short short article on Page E-24, "How To Treat the Old Girl" you might send for the Navy Management Office's cartoon illustrated booklet called "Writing Out Loud." This not only gives some highly interesting cartoon-illustrated background of stone age dictating but also contains some fine points on being a good dictator. For 15¢ the Superintendent of Documents, U. S. Government Printing Office, will rush the volume to you.

Confidings of Our Readers

Our political activities this year have been limited to sending reprints of H. H. Hinson's article in the June, 1956 *Petroleum Engineer* to the chairmen of the McKean County Young Republican Club. Richard R. Newton said he thought the article, "Signposts of Better Management," was most noteworthy. With a man of Mr. Newton's judgment leading young GOP's, we predict that McKean County is pretty Republican this year.

Not long ago we had more requests for the excellent study To Meet Critical Dates." This article by W. G. Snyder neering To Meet Critical Dates." This article by W. G. Snyder is valuable to anyone in planning and scheduling engineering.

This is just to thank Hal Hanson of Oceanic Oil Company for saying that he was very pleased with our articles on supervision, management, education, personnel, and communication.

Robot Device Will Inspect Hurricanes

A complicated instrument will be used by Gulf Oil Corporation to gather data on the forces of waves, winds, tides, and currents in the open sea and in water depths over 100 feet.

This hurricane inspector is an adaptation of existing instruments in two heavy steel, water-tight boxes, each of them smaller than a regular household refrigerator. The "Inspector" will record the height of waves, period between crests and the tide during their occurrence. Wind velocities will be noted by a velocity-direction indicator up to 100 miles per hour. After that, a wind gust indicator will take over.

Objective of the Gulf organization is to learn the strength needed in offshore drilling platforms to protect operating crews and equipment.

Big Brother Is Watching You

All the man below has to do to see who has entered his office reception room is glance at the closed circuit television installation. Robert L. Purcell, executive vice president of Siegler Corporation doesn't look too happy but he's stuck with it. The set is in the Chicago Merchandise Mart. Siegler manufactures electronic devices and power tools. Its staff will just have to get accustomed to interruption by instrument.

Robert L. Purcell inspects company caller.

Earnings 18% Up For 70 Companies

Growth of sales and earnings in the petroleum industry continues remarkably steady. In the first half of 1955 net income for 50 companies increased 12 per cent above the same period in 1954. For the total year 1955, net income was 17 per cent above 1954.

In 1956, for the first six months 70 companies had an increase of 18 per cent in net income over 1955 (See Table).

The second quarter of 1956 has slowed down slightly on earnings but not on revenue. The first quarter showed revenues up 13 per cent and earnings up 20 per cent. This first six months of 1956 showed revenues up the same amount and net income up 18 per cent. Of these 70 companies, only 7 had a net income decrease this first six months and 2 of those had less than 1 per cent change.

Of those who released the data for the first six months, just 2 failed to reach the gross income of 1955. General Crude and Middle States were off 2 per cent from last year.

Dividends are up. Of the 70 companies shown here, 40 had the same dividends for the first half of 1956 as for 1955; 28 had increased dividends, and 2 had less dividends this year.

Possibly the most important factor revealed in all this financial data is the continued small percentage of profits in proportion to sales. This remains 12 per cent for the first six months, about the same as last year. When we hear the complaints about large profits, it will be well to remember that percentage of profit changes little—the industry's expanding volume of sales is the main reason for profit increase.

The second important element is increase in capital expenditures. The first six months showed that every company whose plans were revised, had increased its expansion for 1956 (The Conference Table, July, 1956).

A recent release by Gulf Oil shows its capital expenditure has gone up another $50 million since July. Estimated outlays for 1956 are now more than $400 million instead of the $350 million estimated earlier.

The July Conference Table predicted $7.4 billion capital expenditures this year. It may run even higher. There have been no indications of lowering investments and several indications of increases.

FINANCIAL REPORTS FOR THE FIRST SIX MONTHS — 1956

Company	Gross income $1,000 1956	1955	% of 1955	Net income $1,000 1956	1955	% of 1955	Dividends/Share Common stock 1956	1955
Amerada	$53,336	$50,407	106	$13,552	$12,197	111	1.00	1.00
American Maracaibo	4,539	3,659	124	1,200	1,008	119	0	0
Anderson-Prichard	33,459	28,162	119	2,782	1,915	145	.55*	.40*
Argo Oil	6,078	5,640	108	2,083	2,361	88	.50	.50
Ashland	138,949	121,719	114	7,172	5,119	140	.40+	.30
Atlantic Ref.	277,050	260,656	106	22,181	18,903	117	1.00	1.00
Aztec Oil	1,005	982	102	281	221	127	0	0
Barber Oil	—	—	—	513	108[6]	475	1.25	1.00
Bishop Oil	1,380	990	139	200	158	127	.10	.10
British-American	—	—	—	10,072	9,805	103	.42½	.42½
Chicago Corp.	38,659	31,332	123	4,541	3,603	126	.50	.40
Cities Service	497,931	459,179	108	30,405	25,349	120	1.20+	1.00
Clark Oil and Ref.	36,805	27,146	135	1,299	762	170	4% st.	0
Colorado O. and G.	14,437	11,223	129	1,156	634	182	0	0
Continental	287,398	256,565	112	25,549	22,172	115	1.50	1.40
Cosden Pet.[4]	55,613	50,187	111	4,998	3,546	141	1.50	1.00
Crescent Corp.	—	—	—	363[1]	2,178[1]	—	—	—
Crown Central Pet.	28,887	—	—	440	—	—	—	—
Delhi-Taylor	28,313	25,000	113	1,366	1,311	104	0	0
Drilling & Exploration	5,793	5,285	110	382	391	98	.25	.12½
General Crude	6,373	6,479	98	1,729	1,861	93	.50	.50
Getty Oil [5]	—	6,631	—	3,977	2,433	163	—	—
Gulf Oil	1,083,545	923,631	117	138,072[3]	91,871	150	1.25	1.00
Hugoton Prod.	—	17,320	—	—	6,195	—	1.20	1.00
Hancock Oil	26,891	22,732	118	3,749	2,981	126	.30+	.30+
Honolulu Oil Corp.	20,776	17,320	120	6,861	6,195	111	.80	.50
Humble Oil	590,804	532,426	111	92,361	88,284	105	1.20	1.14
La. Land and Exp.	13,111	12,688	103	7,060	6,933	102	.55*	.50*
Macmillan	942	601	157	99	36	275	0	0
Maracaibo	1,120	977	115	278	181	154	.18	.18
Middle States Pet.	5,242	5,367	98	606	614	99	0	4% st.
Midwest Oil	7,926	6,981	114	3,385	3,010	112	.70	.70
Monterey	9,339	6,435	145	705	415	170	.40	.40
Nortex O. and G.	—	—	—	171	125	137	0	0
Ohio Oil	140,718	126,684	111	21,276	19,551	109	.80*	.77½*
Panhandle Oil	7,435	6,216	120	546	366	149	3% st.	.15
Phillips Pet.	507,954	430,016	118	51,566	42,576	121	.75*	.75*
Plymouth Oil	—	49,147	—	4,257	3,895	109	.80	.80
Pure Oil	251,286	239,333	105	17,826	16,081	111	.80	.65
Pyramid Oil and Gas	—	—	—	(51)	(158)	—	0	0
Quaker State	28,298	24,791	114	1,192	1,208	99	1.00	1.00
Richfield	123,240	123,747	100	14,532	14,635	99	1.50	1.50
Seaboard	22,963	21,079	109	4,975	4,049	123	.50	.50
Shamrock	25,559	20,327	126	4,716	3,913	121	1.00	1.00
Shell	791,574	713,466	111	69,441	54,497	127	1.00	1.00
Signal	10,585	9,301	114	4,568	4,080	112	.30	.30
Sinclair	596,703	535,591	111	45,104	37,801	119	1.50	1.30
Skelly	125,839	111,205	113	15,540	14,823	105	.90	.90
Socony Mobil	—	—	—	123,771	99,589	124	.80*	.80*
South Penn	32,775	27,782	118	2,932	2,085[11]	131	1.00	1.00
Southern Prod.	8,730	8,580	102	2,335	2,239	104	.50	.25
Standard Calif.	740,261	649,874	114	122,050	109,343	112	.75*	.714*
Standard Ind.	947,910	864,985	110	75,904	64,965	117	.70	.70
Standard Jersey	3,494,000	3,071,000	114	392,000	344,000	114	1.00*	.63½*
Standard Ohio	195,125	177,175	110	13,451	10,173[1]	132	1.12½*	.83⅓*
Sun Oil	350,476	323,663	108	25,139	24,407	103	.50	.50
Sunray Mid-Con.	167,171	147,509	113	20,247	17,444	116	.60	.60
Superior[10]	40,434	35,621	114	3,065	4,063	75	0	1.00
Texas Co.	1,027,116	891,407	115	138,089	124,834[9]	111	.90	.75
Texas Gulf Prod.	8,364	7,996	105	3,193	3,068	104	.60*	.40*
Texas National	781	629[7]	124	209	34[7]	615	0	0
Texas Pacific	11,891	11,781	101	3,766	4,121	91	.50*	.35*
Tidewater Oil	259,161	239,284	108	21,599	18,022	120	5% st.	5% st.
TXL	—	—	—	1,958[3]	1,495[3]	131	0	0
Union Oil of Calif.	192,028	175,863	109	13,618	16,309	83	1.20	1.20
Union O.&G. of La.	13,880	11,530	120	1,995	616	324	.40	.37½
Universal Consol.	3,922	2,700	145	1,754	1,008	174	1.30*	.83*
White Eagle	5,963	4,474	133	1,550	1,062	146	St.	.10+
Wilcox Oil	4,349	4,230	103	542	431	126	.50	.50
Woodley Pet.	2,804	1,958	143	964	485	199	.25+	.25
TOTAL	**$13,386,106**	**$11,893,566**	**113**	**$1,615,022**	**$1,373,221**	**118**	—	—

* Adjusted for stock dividends already distributed.
+ Plus Stock.
( ) Loss

[1] Most earnings arose from sales of property.
[2] Six months ending May 31.
[3] Includes Warren Petroleum income from March 1.
[4] Report for years ending April 30.
[5] Includes non-recurring profit of $1,602,000.
[6] Does not include $14,161,000 realized from sale of American Republic Corp.
[7] Texas National Petroleum was formed last year by merger of Texam Oil and Gas Co. and Johnson Oil and Gas Co. These are combined figures.
[8] Formerly Pacific Western Oil Corp.
[9] Includes non-recurring profit of $8,185,000.
[10] Nine months ending May 31.
[11] Does not include sale of Gulf Oil Shares for $1,392,000.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Suez Canal seizure by Nasser of Egypt is providing domestic oil producers with new "cannon fodder" in their fight to cut foreign crude imports. Russell Brown, general counsel of the IPAA, pointed out in a recent Tulsa meeting that the United States and the free world cannot place much dependence on Middle East oil in case of war or an emergency. French Robertson, president of the Texas Mid-Continent Oil & Gas Association contends that Texas oil could make up a total Middle East import deficit simply by increasing the state's production schedule from 16 to 18 days per month.

★ ★ ★

"Too much of everything" is the oil industry's main trouble, says Frank M. Porter, president of the American Petroleum Institute. The API leader told Tulsa oil writer Andrew Rowley recently that "Refiners are running too much crude oil to stills; producers are bringing too much crude oil to the surface; and importers are bringing into the United States too much crude oil."

★ ★ ★

Oil Industry Information Committee has been awarded its sixth citation in five years from Freedom's Foundation. The award was made for helping to bring about a better understanding of the American way of life through the American Petroleum Institute School Program.

★ ★ ★

Engineer starting salaries continue to climb, statistics of the Illinois Institute of Technology indicate. 1956 graduates are earning an average of $391 per month — an increase of over $100 since 1949 when the average was $282. Last year's average was $383. Significant salary increase has been noted for chemical engineering graduates — from $365 in 1955 to $424 this year.

★ ★ ★

Trans-Arabian Pipe Line Company has filed a protest with the Lebanese government against new laws calling for "retroactive taxation" back to January, 1952, on foreign companies which had previously been granted legal exemptions. The Company has indicated that the new rule violates the terms of the convention under which Tapline has been operating. Officials of the 1068-mile line recently proposed a profit-sharing agreement under which the shares of the four countries through which the company's pipe line passes would amount to a total of 50 per cent. Tapline has not yet withdrawn the offer.

★ ★ ★

"Romance of Oil" is the subject selected by H. M. S. Burns, Shell Oil president, for one of the featured talks of this fall's Desk and Derrick convention in New Orleans, Louisiana, according to Miss Edna Hurry, president. Pan-Am Southern Corporation's Bruce K. Brown will also be heard at the fifth annual meeting, September 7-8. Mrs. Sybil Sureck, Oklahoma City, 1955 association president, will deliver the keynote address.

★ ★ ★

Sixteen scholarships have been granted by the Atlantic Refining Company for the academic year beginning this month. The scholarships will go to 12 undergraduates and 4 graduate students in colleges and universities in the South, Southwest, and Midwest. This is the fourth year of Atlantic's annual scholarship program to encourage and assist promising students in the fields of science, engineering, and research directly related to petroleum industry operations.

★ ★ ★

First Venezuelan oil concession since 1945 has been granted to a joint venture group comprised of subsidiaries of Pure Oil, Signal Oil and Gas, Hancock Oil, and Ohio Standard companies. The concession, to be shared equally by the four firms, totals 28,000 acres in the east-central area of Lake Maracaibo. The group is now conducting geophysical studies, expecting to begin test drilling at an early date.

★ ★ ★

Major oil importing companies have agreed to continue gathering their oil statistics "according to the rules" recently set up by the government. Statistics are now being collected by the Foreign Petroleum Supply Committee —all government employees—limiting the amount of compiled information that is available to the companies. Purpose of the new committee is to avoid the possible antitrust dangers of making production quota agreements.

Depletion allowance inquiry is being considered, a formal announcement by Senator Murray of Montana reveals. Murray, chairman of the Senate interior committee, says he has in mind making a complete study to "find out what effect percentage depletion has on the rate of domestic production of minerals — including oil. The effect . . . in inducing venture capital is fairly well known, especially in the oil business." Whether the percentage is too high or too low has not been adequately studied, Murray contends.

★ ★ ★

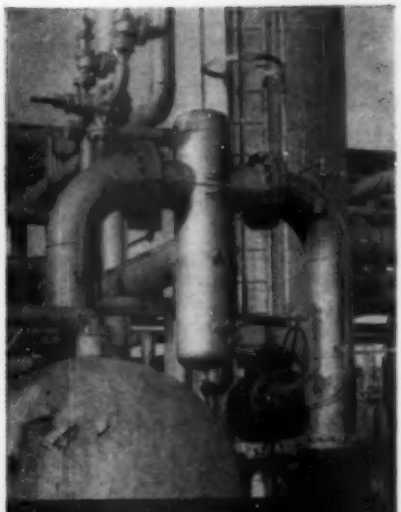
Natural gas will make its official entry into the Pacific Northwest this month with delivery of the fuel to the Portland, Oregon, region by the Pacific Northwest Pipeline Corporation. The company's newly-completed 1487-mile line, bringing gas from New Mexico, Colorado, and Wyoming, will soon be extended to Tacoma and Seattle markets.

★ ★ ★

Domestic oil producers have joined together demanding sharp cutbacks by the government in oil imports. Nineteen oil and gas producers assoications have filed a formal petition with Defense Mobilizer Arthur Flemming, thus assuring a public hearing on the request, probably next month. The producers, spurred by TIPRO and representing groups from California to Pennsylvania and Texas to Kansas, say that under the voluntary formula imports should equal about 16.6 per cent of domestic production, but have instead been running about 20 per cent of production.

★ ★ ★

U. S. tanker fleet is losing its rating on the seas, reports Sun Oil Company. At the end of 1955 top-ranked American tankers carried 20.8 per cent of the world's oil, the U. S. had 23 per cent of the carrying capacity in 1954, and in 1945 was hauling 60 per cent. At the present rate of tanker construction, this country will fall to third place, behind the United Kingdom and Norway, by 1960. Sun's report noted that Liberia, who has purchased several vessels since 1952, is now carrying 10.9 per cent of the world's oil. Eight tankers are now under construction in U. S. yards, while Great Britain alone is building 137 new vessels.



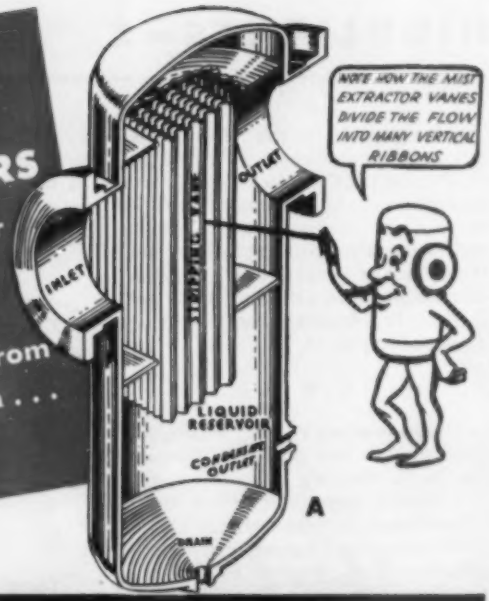
A Peerless Line Separator is shown above removing entrainment from a refinery reboiler.

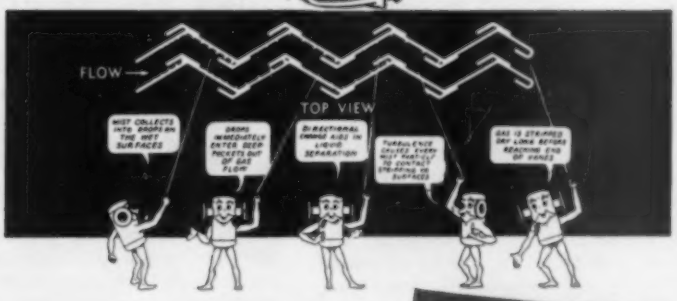
Peerless Line Separators are doing an effective job of mist extraction at this Kentucky Petrochemical Plant.

This is an insulated Peerless Steam Separator on a turbine driving an airblower.

PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .





HIGH EFFICIENCY — HIGH CAPACITY LOW PRESSURE DROP

Thousands of installations throughout the Refining and Chemical industry have proven the Peerless Line Separator principle to be one of the most outstanding methods available for the extraction of liquid from gas, steam or air.

Drawing A above shows the arrangement of the vanes in the Separator. Drawing B is an illustration of the Peerless principle.

The mist extractor combines the forces of impingement, centrifugal motion and surface tension to obtain its high efficiency. The path of the gas, etc., through the unit is constantly bending, causing semi-violent turbulence and rolling of the gas against the walls of the vane. Impingement and centrifugal force combine to contact the droplets with the vanes, where they coalesce, and surface tension then causes them to cling to the vanes' surfaces. Gravity and the impact of the gas stream then drives the droplets into the pockets where they roll down the vanes and out of the gas stream.

Through the Peerless method of mist extraction, the gas is stripped dry long before reaching the end of the vanes.

there's A PEERLESS SEPARATOR FOR EVERY REQUIREMENT

For any capacity
For any working pressure
For corrosive conditions
With removable vane units
With extra body length
With connections for accessory equipment
For pressure drop requirements of less than 6" water
For any vapor-liquid ratio
For any piping requirement

SPECIAL DESIGN SEPARATORS FOR ANY REQUIREMENT

FOR FURTHER INFORMATION ON THE USE OF PEERLESS LINE SEPARATORS PLEASE WRITE FOR NAME OF NEAREST PEERLESS ENGINEER.

PEERLESS MFG. CO.

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 ★ DALLAS 20, TEXAS ★ Dixon 8431

REPRESENTATIVES IN ALL PRINCIPAL CITIES

"Progress" is the title of a new monthly newspaper published by the Burmah Oil Company. The journal, datelined Karachi, Pakistan, tells of operations and activities of the three Burmah companies operating in East and West Pakistan — the B. O. C., Ltd., Sui Gas Transmission Company, Ltd., and Pakistan Petroleum Limited. First issue appeared August 15.

★ ★ ★

"Automation Week" has been proclaimed in New York City November 26-30. Planning of several events is underway, highlighted by the Third International Automation Exposition. Conferences on "Automation for the Office" and on "Human Engineering for Automation" have been scheduled, as well as a hundred clinics in different aspects of automation. During the close of the same week, in New York, the annual meeting of the American Society of Mechanical Enginesrs will convene.

★ ★ ★

Bought . . Sold . . . Merged: *Colorado Oil & Gas Company* negotiations to buy the British-owned *Trinidad Petroleum Development Company* are well underway, official statements report, but indicate that it will be "several weeks before anything develops." . . . *Texas Company-Trinidad* negotiations are continuing . . . *Sinclair Oil Corporation* has contracted to buy about 1,110,000 shares of *Texas Pacific Coal & Oil* stock from a group of investors for an estimated $47,000,000. Texas Pacific still has about 3,600,000 shares of stock outstanding. . . . *Southern Production Company, Inc.*, oil and gas properties sale to *Sinclair Oil* subsidiaries is advancing to final stages. This transaction involves exchange of some $60,500,000 cash after debt retirement of about $47,000,000 . . . Southern Production's remaining assets, principally interest in *The Offshore Company*, would be sold to *Southern Natural Gas Company* . . . Merger of *Mul-Berry Oil Company* of Cushing, Oklahoma, and *Blackwell Oil & Gas Company*, Tulsa, has been approved by directors of the two firms . . . *Sunset International Petroleum Corporation* is the new organization stemming from recent combination of *Sunset Oil Company*, Los Angeles, California, and *International Mining Corporation*, an investment company located in San Antonio, Texas. Sunset is an operating oil producer as well as owner of refinery and lube plants in California . . . *Cosden Petroleum Company*, Big Spring, Texas, has purchased one-third interest in the *Blanco Oil Company, et al*, properties formerly owned by *Newman Brothers Drilling Company*.

★ ★ ★

German gasoline consumption is reaching new peaks. A survey of the first five months of this year, shows that auto fuel deliveries rose steeply — 23.3 per cent higher than in May 1955. Total consumption, according German Mineral Oil Office, was 279,000 tons for May, 1956.

★ ★ ★

Texas Mid-Continent Oil & Gas Association is making final plans for its 37th annual meeting in Houston, October 2-3. General Arrangements Chairman D. L. Connelly, Warren Petroleum Company, has announced these committee assignments: reception, John R. Suman; golf tournament, Ed Tyer; hotel reservations, C. W. Alcorn; press arrangements, James A. Clark; convention registration, J. D. Wheeler; transportation, Amos A. Roberts; entertainment, Harry Hurt, and ladies entertainment, Mrs. Herman P. Pressler.

★ ★ ★

Military purchases of petroleum products and services have passed the $1 billion mark during the fiscal year 1956 — for the first time in the history of the Armed Services Petroleum Purchasing Agency, according to Captain C. G. Drescher, director. The amount represents 233,000,000 bbl of products, 125 storage contracts, and other services. The military oil requirements are at their highest level since the peak of World War II.

★ ★ ★

Oil interest joint or co-owners engaged in drilling, development, operation, payment of lease rentals, etc., should file the Internal Revenue Department form 1065 before October 15. Failure to do so may mean additional income taxes. Also operators must file IRS form 1099 before each partnership deal. Danger lies in possibility of losing charge-off of any drilling or development expense deducted from 1955 income tax returns. These expenses would have to be capitalized as "lease cost" recoverable only through cost depletion in most cases.

Improved pension plan has been put into effect for employees of the Esso Standard Oil Company. The changes, affecting employees in the company's 18-state operating area, would provide higher retirement income, increased early retirement allowances and liberalization in the crediting of company service for all periods of service regardless of breaks of employment. Employees entitled to $182 a month under the old plan will get $227 under the new.

★ ★ ★

Some oil executives and engineers are expected to be in Dallas September 23-26 for the eleventh annual Petroleum Mechanical Engineering Conference. The meeting is being sponsored by the petroleum division, American Society of Mechanical Engineers. Included on the program are 34 technical papers dealing with engineering problems in all phases of the industry.

★ ★ ★

Foreign oil investments by U. S. firms rose $5.8 billion in 1955, the Commerce Department's Office of Business Economics reports. The amount represents nearly 20 per cent of the total private American investments abroad, estimated at $29 billion, up $2.4 billion during the year. Notable upturn was seen in Latin American oil investments, with some increase in Australia, Union of South Africa, Indonesia and Japan.

★ ★ ★

Oil nationalization in Burma is being prevented by lack of trained personnel, states U Nu, former Burmese premier. According the former leader, Burma could easily raise the $42,000,000 needed to compensate oil companies in his country, currently operating in joint ventures with the state. Under the present arrangement, Burma has the right to take over the company under payment of just compensation for company stock.

★ ★ ★

Higher employment records are being set. In mid-July, date of the last government count, the nation's employment hit 66,700,000—a record for the second straight month. Commerce and Labor departments reported that job-holders increased 152,000 over mid-June, up 1,600,000 over the same period last year. Unemployment stands at 2,800,000, or about 4 per cent of the total labor force.

Dowell engineers use Retarded Acid to provide maximum penetration and increased drainage area.

Retarded Acid bites deep into pay

Regular acids often become spent near the well bore in fast-reacting vugular or fractured limestone. Retarded Acid, however, has a special additive that delays its punch—allows it to penetrate deep into the pay before becoming spent. This helps you reach production that might otherwise remain trapped far from the well bore.

Now Dowell research offers you more than one kind of Retarded Acid. A new development uses the Acid Petrofrac* emulsion as the treating solution. The right kind for your well depends on formation conditions. Because of its high acid content, retarded acid action, low-fluid-loss and silicate-control properties, Dowell engineers may recommend this use of the Acid Petrofrac emulsion to you.

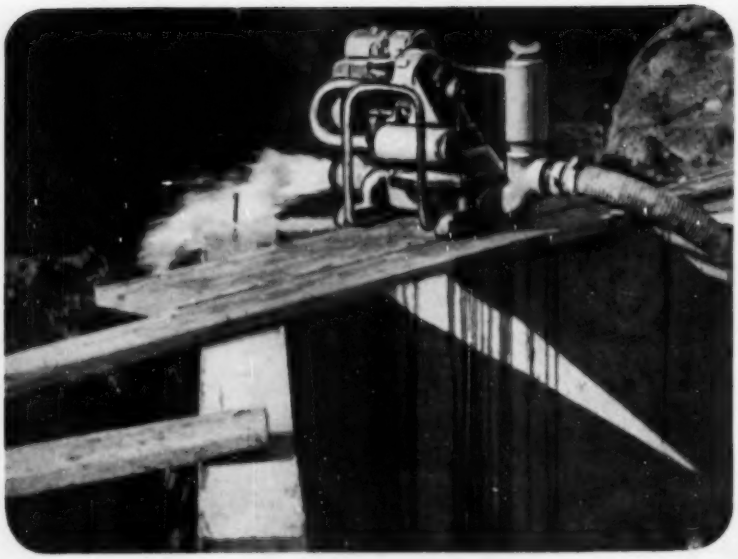
Let a Dowell engineer examine your well. He's an expert at prescribing the right treatment. And, too, your Dowell engineer has at his disposal the widest variety of services and treating materials in the oil fields.

For more information, or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. I-12.

*Service Mark of Dowell Incorporated

services for the oil industry DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

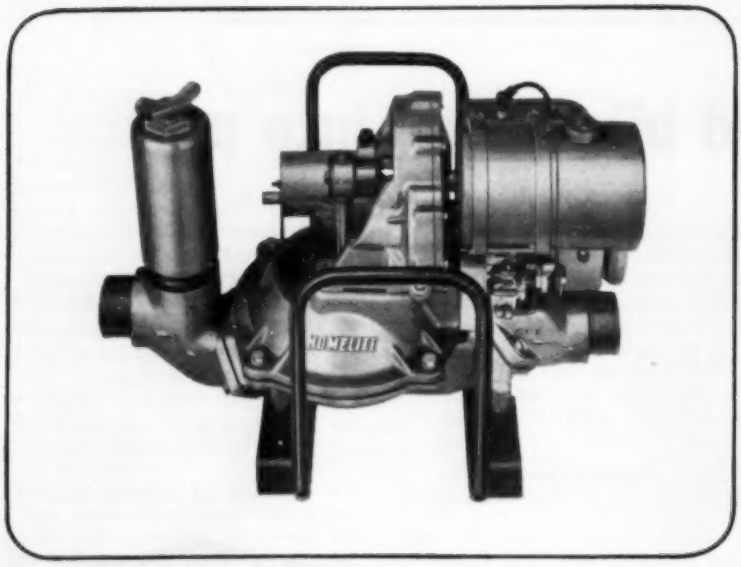


It's here!
The new heavy-duty diaphragm pump that's light enough to carry

Here's the diaphragm pump that goes most easily to the job and does more when it gets there. Specifically designed for continuous, heavy-duty work, this Homelite pump will dewater an area at a 5000 g.p.h. clip, then keep right on going to handle seepage in the thickest mud, muck and sand. Yet, because it weighs only 120 pounds, it gets to the job fast . . . even over the roughest terrain.

The entire unit is built for long, trouble-free operation. Manual throttle control adjusts engine speed for full-capacity pumping or handling small seepage flow . . . gives greater fuel economy and prolongs engine life. Ball and roller bearings protect engine and pump from excessive wear. Totally enclosed reduction gears run in oil. Tough, oil-resistant diaphragm can be easily replaced in ten minutes right on the job.

For more information or a demonstration on your job, write or call your nearest Homelite representative.



NEW HOMELITE
Carryable
DIAPHRAGM PUMP

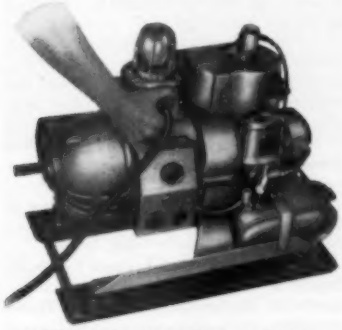
Model 20DP3-1 has guaranteed total lift up to 28′ and total head up to 50′, including friction.

HOMELITE

A DIVISION OF TEXTRON INC.
4709 RIVERDALE AVENUE
PORT CHESTER, NEW YORK

CHOOSE
from a full line of
HOMELITE
Carryable
Construction
Equipment

SELF-PRIMING CENTRIFUGAL AND DIAPHRAGM PUMPS
Sizes: 1½" to 3" — capacities to 15,000 g.p.h. for dewatering and water supply.



ELECTRIC GENERATOR SETS FOR TOOLS AND LIGHTS
Complete range of sizes and voltages up to 5,000 watts.

LIGHTWEIGHT POWERFUL ONE-MAN CHAIN SAWS,
Complete line of saws with clearing and brushcutter attachments for every woodcutting job.

HOMELITE
A DIVISION OF TEXTRON INC.
PORT CHESTER, N. Y.

Meetings

Sept. 5-7—**Wyoming Geological Association,** 11th annual field conference, Jackson Lake Lodge, Moran, Wyoming.

Sept. 6-7—**American Petroleum Institute,** Oil Industry Information Committee, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 7-8—**Association of Desk and Derrick Clubs of North America,** 5th annual convention, New Orleans, Louisiana.

Sept. 9-12—**American Institute of Chemical Engineers,** William Penn Hotel, Pittsburgh, Pennsylvania.

Sept. 10-14—**Corrosion Short Course,** sponsored by National Association of Corrosion Engineers and department of metallurgical engineering at Ohio State University, on campus, Columbus, Ohio.

Sept. 10-14—**International Congress on Catalysts,** Bellevue-Stratford Hotel, Philadelphia, Pennsylvania.

Sept. 11-13—**Pacific Coast Gas Association,** annual meeting, Coronado, California.

Sept. 12-14—**National Petroleum Association,** annual meeting. Traymore Hotel, Atlantic City, New Jersey.

Sept. 12-14—**Third Annual Electrical Conference of the Petroleum Industry,** sponsored by American Institute of Electrical Engineers and Kansas City Section of AIEE, Kansas City, Missouri.

Sept. 16-18—**Pennsylvania Petroleum Association,** annual meeting, Pocono Manor Inn, Pocono Manor, Pennsylvania.

Sept. 16-18—**New Mexico Petroleum Industries Committee,** annual meeting, Hilton Hotel, Albuquerque, New Mexico.

Sept. 16-21—**American Chemical Society,** 130th annual meeting, Atlantic City, New Jersey.

Sept. 16-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

Sept. 17-21—**Instrument Society of America,** annual, Instrument-Automation Conference and Exhibit (International), New York Coliseum, New York.

Sept. 20-21—**Sixth Annual Corrosion Control Course,** sponsored by Shreveport section, National Association of Corrosion Engineers, on campus of Centenary College, Shreveport, Louisiana.

Sept. 20-21—**Mid-Continent Oil and Gas Association,** La.-Ark. division membership meeting, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 20-21—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting, Hotel Henning, Casper, Wyoming.

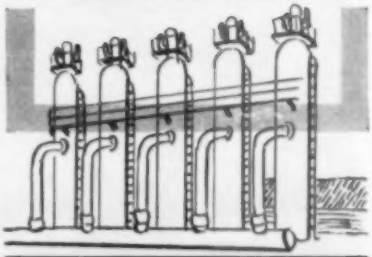
Sept. 23-26—**American Society of Mechanical Engineers,** 1956 petroleum mechanical engineering conference, Statler Hilton Hotel, Dallas, Texas.

Sept. 26—**American Petroleum Institute,** Executive Committee of the Board of Directors, Greenbrier Hotel, White Sulphur Springs, West Virginia.

Sept. 26-28—**American Institute of Mining, Metallurgical & Petroleum Engineers,** Rocky Mountain mineral conference, Newhouse Hotel, Salt Lake City.

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

FEWER
"TURN-AROUNDS"



Shutdowns for repairs of fire clay linings in refractory units are expensive. The frequency and duration of these shutdowns can be greatly reduced by the use of a steel grating armor known as "Gridsteel", which holds the castable refractory linings in place longer and armors them against the bombardment of catalytic elements.

"Gridsteel" is available in a special loose clinch to conform easily to curved surfaces.

For complete information, write for brochure on Irving "Gridsteel" Contour Retainer Mesh

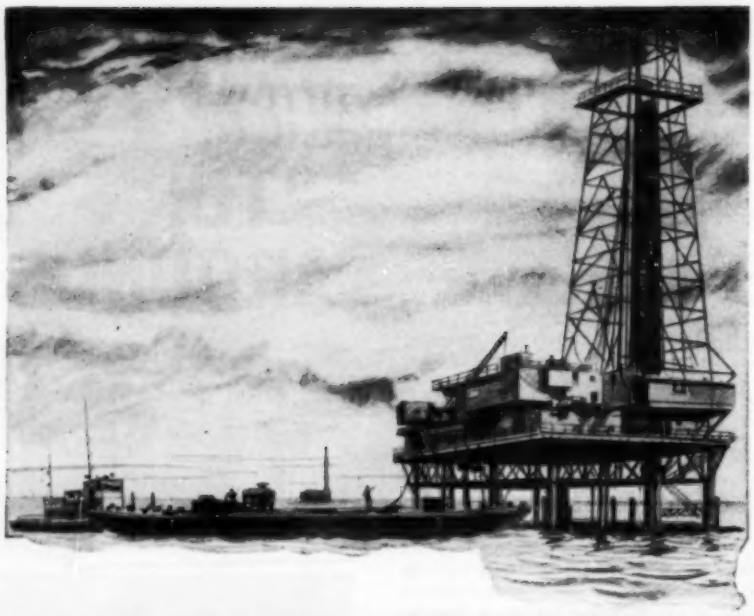
★

"A Fitting Grating for Every Purpose"

IRVICO

IRVING SUBWAY GRATING CO., Inc.
Originators of the Grating Industry

Offices and Plants at
5063 27th St., LONG ISLAND CITY 1, N. Y.
1863 10th St., OAKLAND 23, CALIFORNIA



24 SERVICE-FREE MONTHS FOR GORMAN-RUPP PUMPS

Petroleum Distributing Company finds Model 06B-B Pumps give outstanding performance on "floating filling stations"

On tank barges that supply gasoline, diesel and fuel oil to storage for offshore drilling supply, Petroleum Distributing Company experienced unusual difficulty in keeping their positive displacement pumps operating. In a very brief time, pumps on one barge failed four times in a row.

Mr. James George, Manager of Operations for the New Orleans branch, reports: "In the two years since placing Gorman-Rupp 'O' Series Pumps on the job, we haven't had to spend one cent on maintenance. Just one of these 6" pumps handles both loading and discharge for a 2500-barrel capacity barge. Now we can complete our delivery to offshore storage in less than a half-hour visit."

Send coupon below to our Mid-Continent Gulf Coast Oilfield Representative for the Gorman-Rupp Oilfield Catalog that describes these unique *centrifugal pumps that prime*. They have straight-in suction and no check valve. The valuable 24-page catalog also includes the many other models of Gorman-Rupp Pumps useful in your business.

Gorman-Rupp

THE GORMAN-RUPP COMPANY

305 Bowman Street • Mansfield, Ohio

FREE!

HENRY H. PARIS DISTRIBUTOR, INC.
1125 Rothwell St., Houston, Texas

Please send me the Gorman-Rupp Oilfield Pump Catalog

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Oct. 2-3—**Texas Mid-Continent Oil & Gas Association,** 37th annual meeting, Rice Hotel, Houston, Texas.

Oct. 2-4—**National Association of Corrosion Engineers,** South central region, Beaumont, Texas.

Oct. 7-9—**American Association of Oil-well Drilling Contractors,** 16th annual meeting, Texas Hotel, Fort Worth, Texas.

Oct. 8-12—**American Society for Metals,** 38th annual National Metal Congress and Exposition, Public Auditorium, Cleveland, Ohio.

Oct. 14-17—**American Institute of Mining, Metallurgical and Petroleum Engineers,** fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 17-18—**Indiana Independent Petroleum Association,** Severin Hotel, Indianapolis, Indiana.

Oct. 18-19—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting. Rufus Garrett Hotel, El Dorado, Arkansas.

Oct. 22-24—**Rocky Mountain Oil & Gas Association,** annual meeting, Cosmopolitan Hotel, Denver, Colorado.

Oct. 23-26—**National Association of Corrosion Engineers,** annual south central region meeting, San Antonio, Texas.

Oct. 25-26—**Independent Petroleum Association of America,** annual membership, Mayo Hotel, Tulsa, Oklahoma.

Oct. 29-30—**Petroleum Engineering Conference on Water Flooding,** sponsored by Illinois State Geological Survey, on the University of Illinois Campus, Urbana, Illinois.

Oct. 29-30—**Independent Petroleum Association of America,** 27th annual meeting, Statler Hilton Hotel, Dallas, Texas.

Oct. 29-Nov. 1—**Society of Exploration Geophysicists,** national convention, Roosevelt Hotel, New Orleans, Louisiana.

Oct. 31-Nov. 2—**Gulf Coast Association of Geological Societies,** 6th annual convention, Plaza Hotel, San Antonio, Texas.

Nov. 1-2—**Louisiana Polytechnic Institute,** School of Engineering, 5th annual Instrumentation Conference, on campus, Ruston, Louisiana.

Nov. 8-9—**National Association of Corrosion Engineers,** southeast region meeting, Charlotte, North Carolina.

Nov. 12-15—**American Petroleum Institute,** 36th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 19-20—**North Texas Secondary Recovery Symposium,** Petroleum branch, AIME, Municipal Auditorium, Wichita Falls, Texas.

Nov. 25-30—**American Society of Mechanical Engineers,** Statler Hotel, New York City.

Dec. 9-12—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, Boston, Massachusetts.

1957

Jan. 14-16—**Pipe Line Contractors Association,** Boca Raton Hotel and Club, Boca Raton, Florida.

Feb. 24-28—**American Institute of Mining, Metallurgical, and Petroleum Engineers,** Annual meeting, Hotels Roosevelt and Jung, New Orleans, Louisiana.

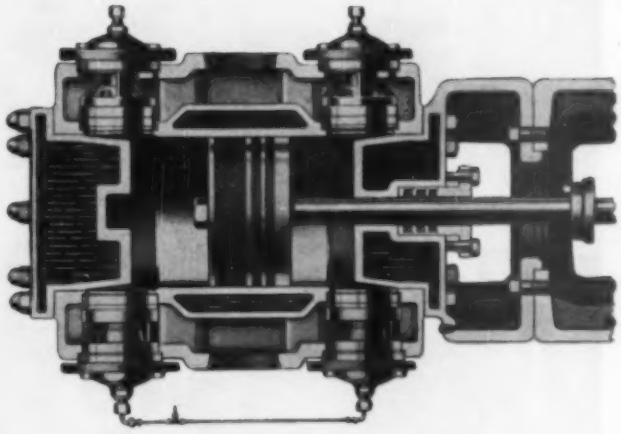
Oct. 9-10—**Third Annual Computer Applications Symposium,** sponsored by Armour Research Foundation of Illinois Institute of Technology, Morrison Hotel, Chicago, Illinois.

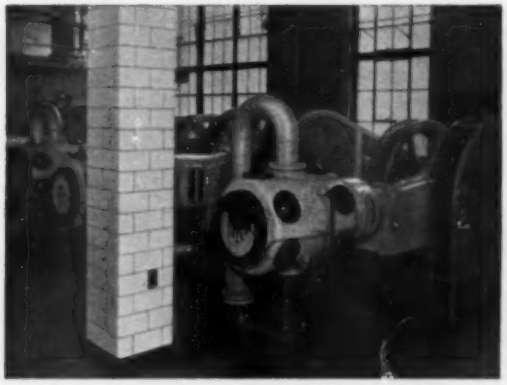
Nov. 30-Dec. 1—**Executive Committee of Interstate Oil Compact Commission,** Wichita, Kansas.

A dependable supply of oil-free air or gas

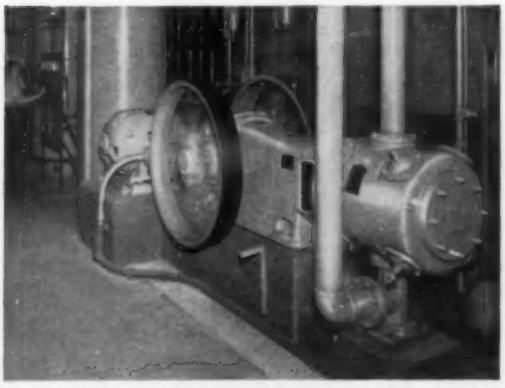
Graphitic-carbon wearing rings and pressure rings prevent metallic contact between the piston and cylinder bore—no oil is used anywhere in the compression cylinder or on the piston rod.

NL Channel Valves are designed specifically for non-lubricated service. Carbon guides protect channel ends and special Teflon strips protect channel interiors and spring ends from metal-to-metal rubbing and wear.





Installed in a large brewery in 1933, this Ingersoll-Rand ES-NL compressor was the first unit ever built with non-lubricated cylinders. It is still in daily service, providing the clean, oil-free compressed air which is vital to product purity. Three other ES-NL compressors, installed since then, are shown in the background.



One of four ES compressors with NL cylinders, supplying oil-free air in the manufacture of super-precision instruments and aircraft ball bearings.

with Ingersoll-Rand ES-NL compressors

In process and manufacturing plants all over the world, the problem of oil contamination in compressed air and gases has been successfully solved by the application of Ingersoll-Rand ES-NL compressors.

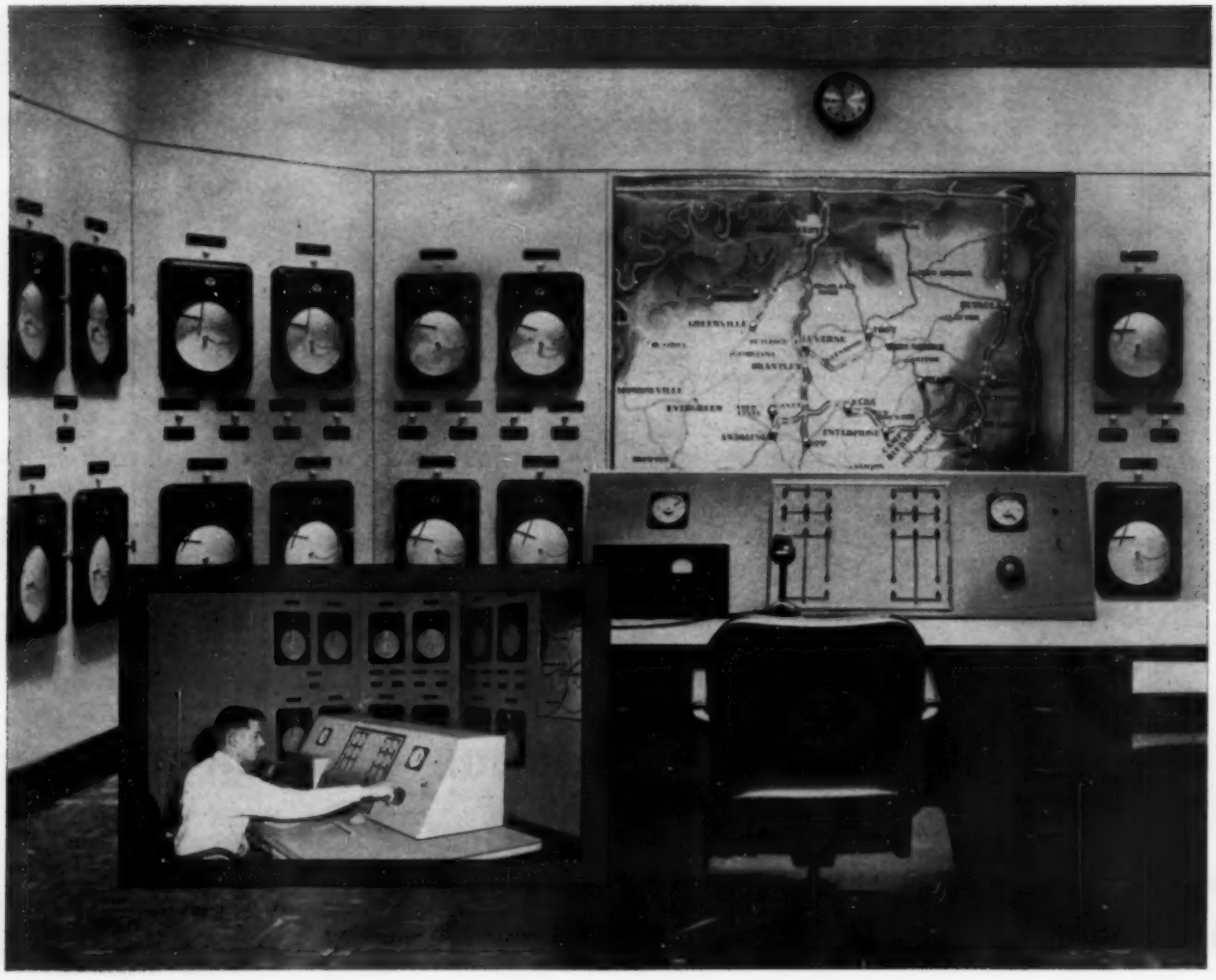
The unique NL cylinder design provides compression without oil lubrication—through the use of graphitic-carbon wearing and pressure rings. The ability of these compressors to deliver clean, oil-free air and gas, in continuous, heavy-duty service, has been thoroughly proved in every field of application.

If you have an application where oil-lubricated compressor cylinders cannot be used, ask your Ingersoll-Rand representative about the ES-NL compressor, sizes 5 to 150 horsepower—other Ingersoll-Rand NL compressors to 1000 hp.

Ingersoll-Rand

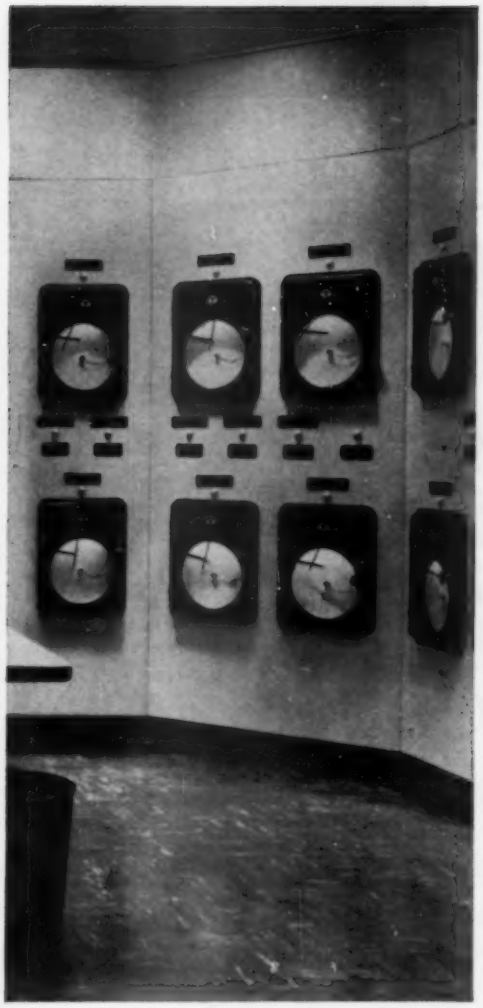
1-422 **11 Broadway, New York 4, N. Y.**

COMPRESSORS • CONDENSERS • AIR & ELECTRIC TOOLS • PUMPS • ROCK DRILLS • GAS & DIESEL ENGINES

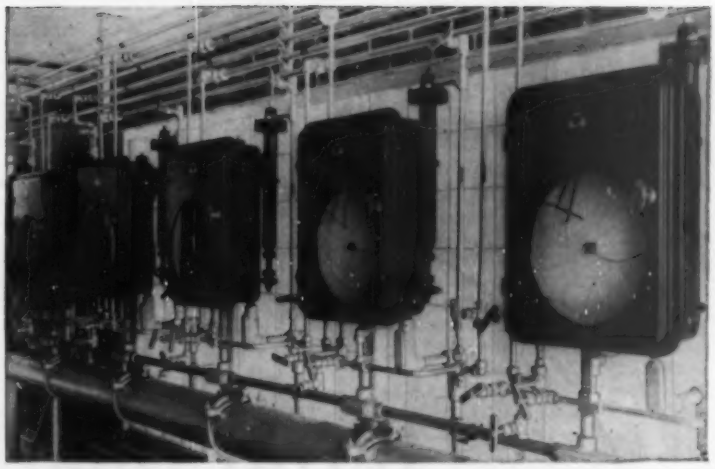


Remote Control of Flow and Pressure for 24 cities and towns in Alabama

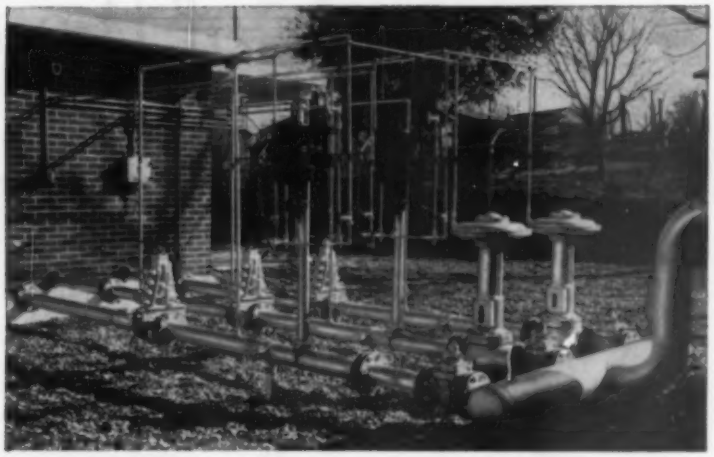
ANOTHER ALL AMERICAN® INSTALLATION — From a centrally located desk in Andalusia, Alabama, one dispatcher, by remote control, regulates the flow of gas for the 24 cities in the Southeast Alabama Gas District—largest municipal natural gas system in the world. The 120 years engineering and precision manufacturing experience of American Meter Company assisted by supplying equipment for this new type modern gas measurement and control installation to bring the advantages of natural GAS to one of the fast-growing areas of the United States.



DISPATCHER STATION – By dialing a single circuit, dispatcher obtains total flow in cubic feet and pressure from each of the 14 city gate stations, plus total flow in cubic feet, pressures and differentials of orifice meters and controllers at each intake station to permit complete remote dispatching.



INTAKE STATIONS — All measurement at intake stations, 90 miles and 120 miles from dispatcher's desk, is combined in a totalizing relay which in turn is put on a memory relay to supply total flow since last dialing.



CITY GATE STATIONS – Each station has American automatic measurement, pressure and regulation equipment, totalizing relays and memory relays, enabling dispatcher to obtain flow for any period and obtain pressures. Complete remote control of dual flow differentials, dual first and second stage regulators.

HIGH PRESSURE RURAL SERVICE REGULATORS

AMERICAN METER COMPANY

INCORPORATED ESTABLISHED 1881

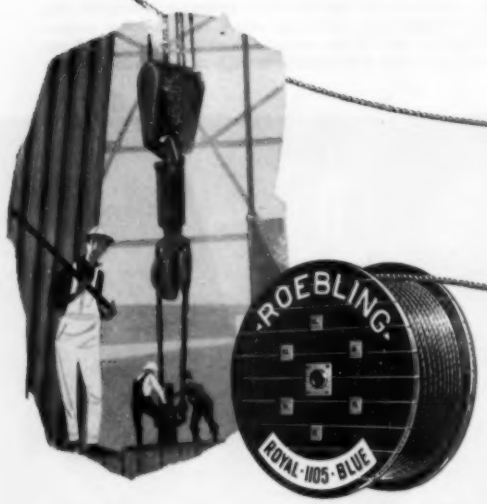
GENERAL SALES OFFICE: Somerton, Philadelphia 16, Penna. • Albany • Alhambra • Atlanta • Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston • Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

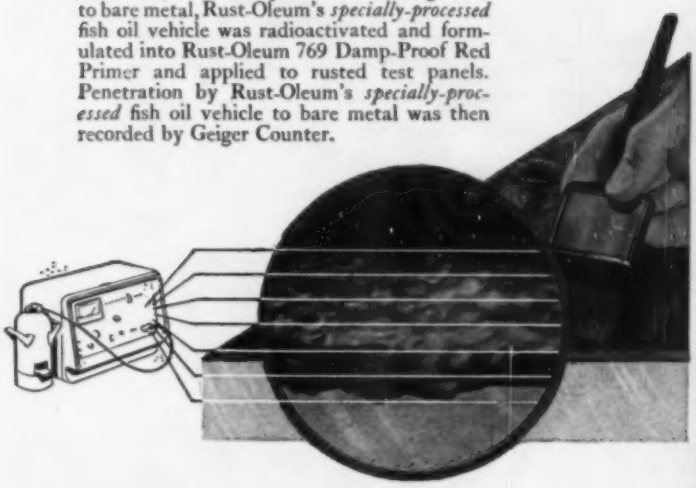
toughest

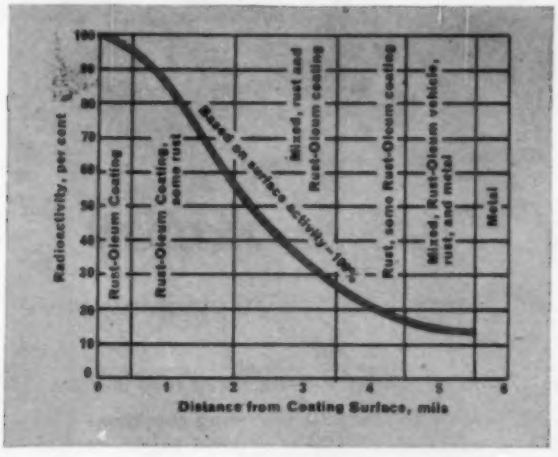
Royal Blue rope is made of the *toughest* rope wire ever developed... Roebling Type 1105



John A. Roebling's Sons Corporation, Trenton 2, N. J., Subsidiary of The Colorado Fuel and Iron Corporation BRANCHES: ATLANTA, 934 AVON AVE. • BOSTON, 51 SLEEPER ST. • CHICAGO, 5525 W. ROOSEVELT RD. • CINCINNATI, 2340 GLENDALE-MILFORD RD., EVENDALE • CLEVELAND, 13225 LAKEWOOD HEIGHTS BLVD. • DENVER, 4801 JACKSON ST. • DETROIT, 915 FISHER BLDG. • HOUSTON, 6216 NAVIGATION BLVD. • LOS ANGELES, 5340 E. HARBOR ST. • NEW YORK, 19 RECTOR ST. • ODESSA, TEXAS, 1920 E. 2ND ST. • PHILADELPHIA, 230 VINE ST. • PITTSBURGH, 1723 HENRY W. OLIVER BLDG. • SAN FRANCISCO, 1740 17TH ST. • SEATTLE, 900 1ST AVE. S. • TULSA, 321 N. CHEYENNE ST. • EXPORT SALES OFFICE, 19 RECTOR ST., NEW YORK 6.

To trace Rust-Oleum penetration through rust to bare metal, Rust-Oleum's *specially-processed* fish oil vehicle was radioactivated and formulated into Rust-Oleum 769 Damp-Proof Red Primer and applied to rusted test panels. Penetration by Rust-Oleum's *specially-processed* fish oil vehicle to bare metal was then recorded by Geiger Counter.





It's easy to actually see Rust-Oleum penetration through rust to bare metal by following the curved line on the graph above. The curved line illustrates Rust-Oleum *penetration* at each mil level down to bare metal as recorded by Geiger Counter and Gas Flow Proportional Counter.

Proved by industry for over 30 years on tanks, girders, roofs, boilers, stacks, wire fences, metal sash, machinery, metal buildings, etc. Excellent, too, for gutters, tools, trucks, under autos, screens, metal furniture, pipes, playground equipment around the home. Rust-Oleum is the modern way to Stop Rust and beautify as you protect. Write for color charts and literature.

See our Catalog in Sweets, or write for complete information. Prompt delivery from industrial Distributor stocks.

Here's what

RUST-OLEUM

penetration means to you!

The results of nearly three years radioactive research prove that Rust-Oleum's *specially-processed* fish oil vehicle penetrates through rust to bare metal.

This penetration enables you to stop rust, because the Rust-Oleum fish oil vehicle soaks through the rust to bare metal and into the tiny pits where it drives out air and moisture that cause rust. Because of this penetration, you can apply Rust-Oleum 769 Damp-Proof Red Primer directly over sound rusted surfaces—usually eliminating costly surface preparations. Rust-Oleum resists salt water, sun, fumes, heat, humidity, and weathering. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," as prepared by Battelle Memorial Institute technologists.

STOP RUST!

with

RUST-OLEUM

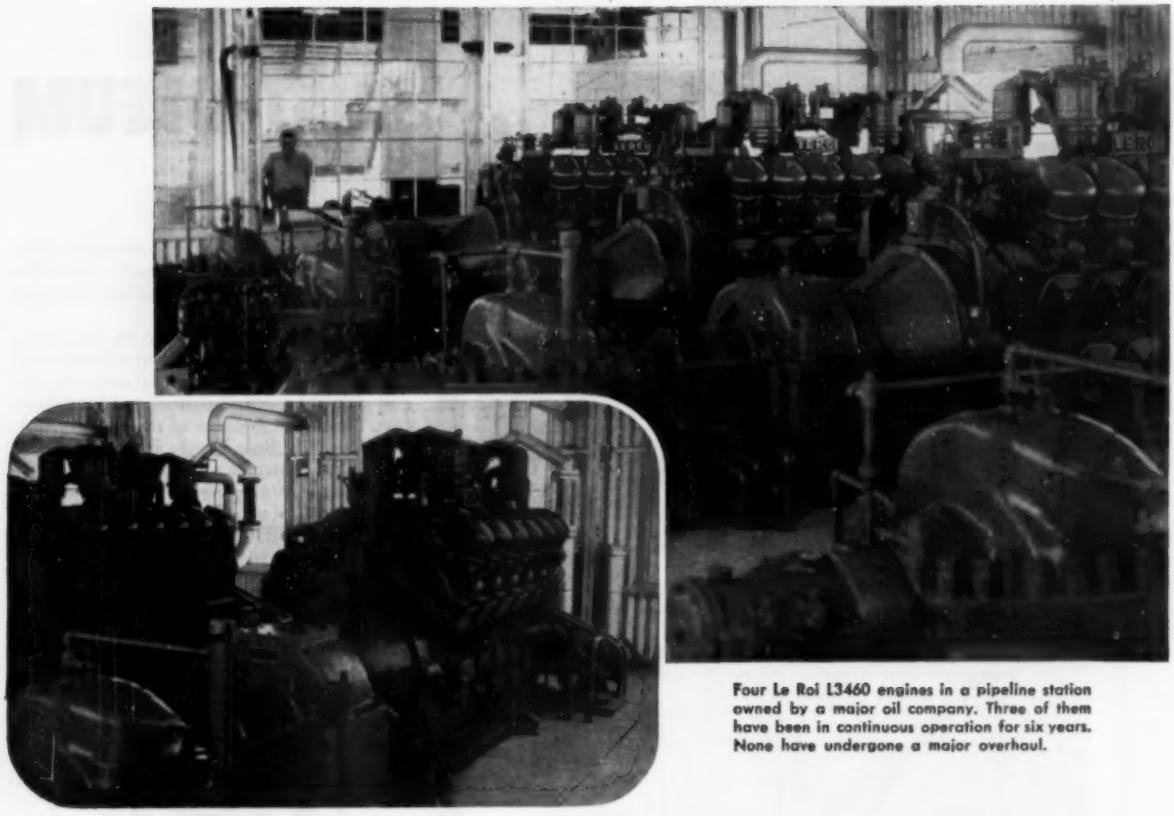
There is only one *Rust-Oleum. It is distinctive as your own fingerprint.*

Rust-Oleum is *exclusive*, using a specially processed fish oil vehicle that penetrates rust to bare metal. Accept no substitute. Buy or specify Rust-Oleum. You'll be happy that you did.

ATTACH TO YOUR LETTERHEAD — MAIL TODAY!

Rust-Oleum Corporation
2502 Oakton Street, Evansville, Ill.

- ☐ Complete literature with color charts.
- ☐ Thirty-page report on Rust-Oleum penetration.
- ☐ Nearest source of supply.



Four Le Roi L3460 engines in a pipeline station owned by a major oil company. Three of them have been in continuous operation for six years. None have undergone a major overhaul.

Power-Packed Pipeline Station

. . . uses Le Roi L3460's to provide plenty of low-cost pumping power

Le Roi's L3460 with 600 max. hp. and its bigger brother, the L4000 with 655 max. hp., are ideal for pipeline service on many counts. Here's why:

Plenty of power with good fuel economy—These engines develop 600 and 655 max. hp. with rock-bottom fuel consumption, and can be run on natural gas, gasoline, or butane. Advanced design manifolding, low friction bearings, and low power loss to accessories, all contribute to unusual operating economy.

Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting—that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

P-140

LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 1, Wisconsin

Teeth that really

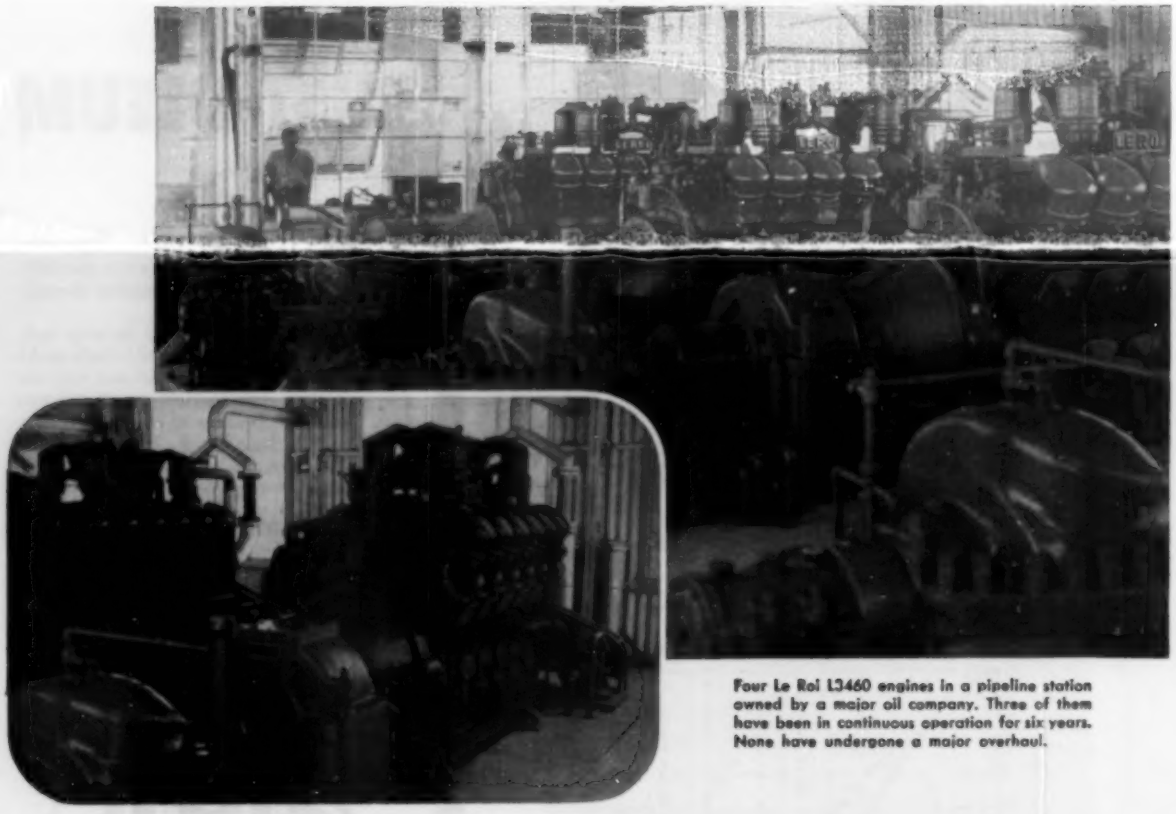
DIG

There is no substitute for forged alloy steel

TOOTH COMPANY

1540 South Greenwood Avenue Montebello, California

25th *Silver Anniversary*



Four Le Roi L3460 engines in a pipeline station owned by a major oil company. Three of them have been in continuous operation for six years. None have undergone a major overhaul.

Power-Packed Pipeline Station

. . . uses Le Roi L3460's to provide plenty of low-cost pumping power

Le Roi's L3460 with 600 max. hp. and its bigger brother, the L4000 with 655 max. hp., are ideal for pipeline service on many counts. Here's why:

Plenty of power with good fuel economy—These engines develop 600 and 655 max. hp. with rock-bottom fuel consumption, and can be run on natural gas, gasoline, or butane. Advanced design manifolding, low friction bearings, and low power loss to accessories, all contribute to unusual operating economy.

Long engine life—Perhaps the best proof of this statement is found in the trouble-free performance experienced by users in installations like the one shown above. Basically the L3460 and L4000 are compact, high-output engines designed with short stroke to give you greater horsepower and speed, without compromising engine life. And that's exactly what they do for you.

More comfortable operating conditions—Water-cooled exhaust manifold cuts down engine heat in operating areas, yet provides fast engine warm-up. The smooth, clean lines of these engines prevent dirt from collecting—that's why they are so easy to keep clean.

Compact V-12 design packs a lot of horsepower in a small space—to give you more horsepower per dollar. This, plus vibrationless performance, reduces foundation costs, simplifies installation.

We think that if you see an L3460 or L4000 in operation you'll agree that they provide the answer to low-cost pumping power. Have your supply house or Le Roi distributor show you one at work. Bulletins are available upon request—just write us.

P-140

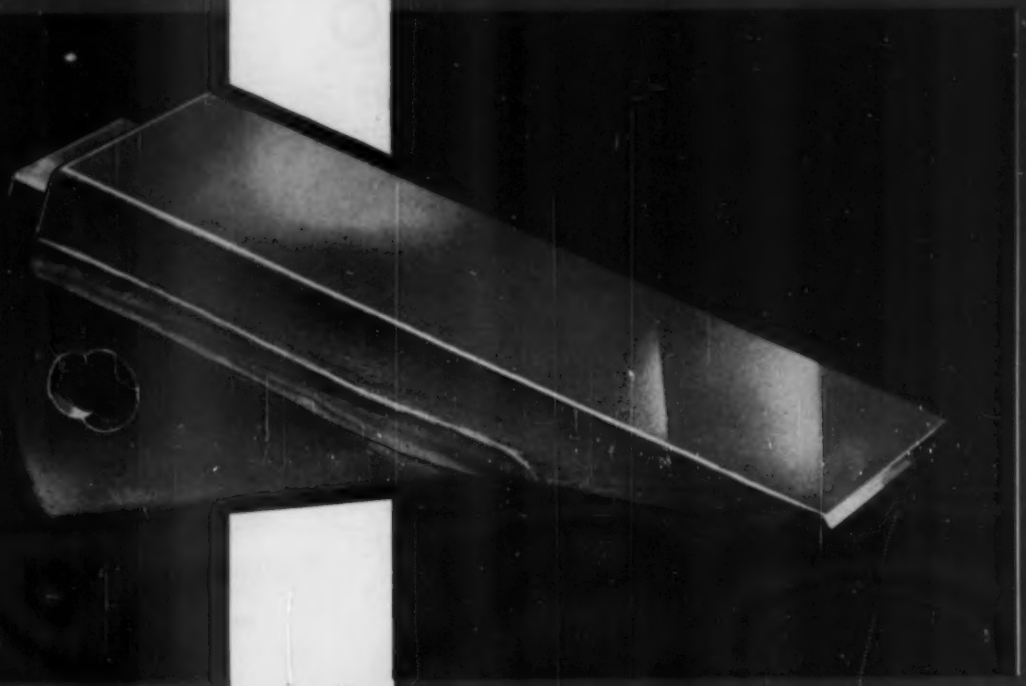
LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 1, Wisconsin

PORTABLE AIR COMPRESSORS · TRACTAIR · STATIONARY AIR COMPRESSORS · AIR TOOLS · ENGINES

Teeth that really

DIG



There is no substitute for forged alloy steel

TOOTH COMPANY

1540 South Greenwood Avenue Montebello, California

25th *Silver Anniversary*

This is your Guarantee . . .

HORTON® FLOATING ROOF
BUILT UNDER ONE OR MORE OF THE FOLLOWING U. S. PATENTS:
TYPE A
FLOATING WEIGHT 202,700 LBS.
CONTRACT NO. G4511
YEAR 1955
CHICAGO BRIDGE & IRON COMPANY
BIRMINGHAM, ALA. CHICAGO, ILL. GREENVILLE, PA. SALT LAKE CITY, UTAH

...OF THE BEST FLOATING ROOF MONEY CAN BUY!

The name plate above tells more than just a few cold facts. Affixed to all Horton® Floating Roofs, it is your assurance of the best roof your money can buy!

Note the UL symbol in the center . . . Underwriters Laboratories, Inc., symbol of approved devices. Horton Floating Roofs have been examined and tested for practicability, durability, strength and fire retardant features by this well known organization.

Write our nearest office for complete information on Horton Floating Roofs . . . Double-Deck, Pontoon or Pan . . . and be sure to ask for a copy of the Underwriters Laboratories report too.

Top: Name plate from storage tank equipped with Horton Floating Roof.

Bottom: Two 80,000-bbl. tanks equipped with Horton Double-Deck Floating Roofs at Edmonds, Washington, refinery of Union Oil Company of California.

CBI

Chicago Bridge & Iron Company

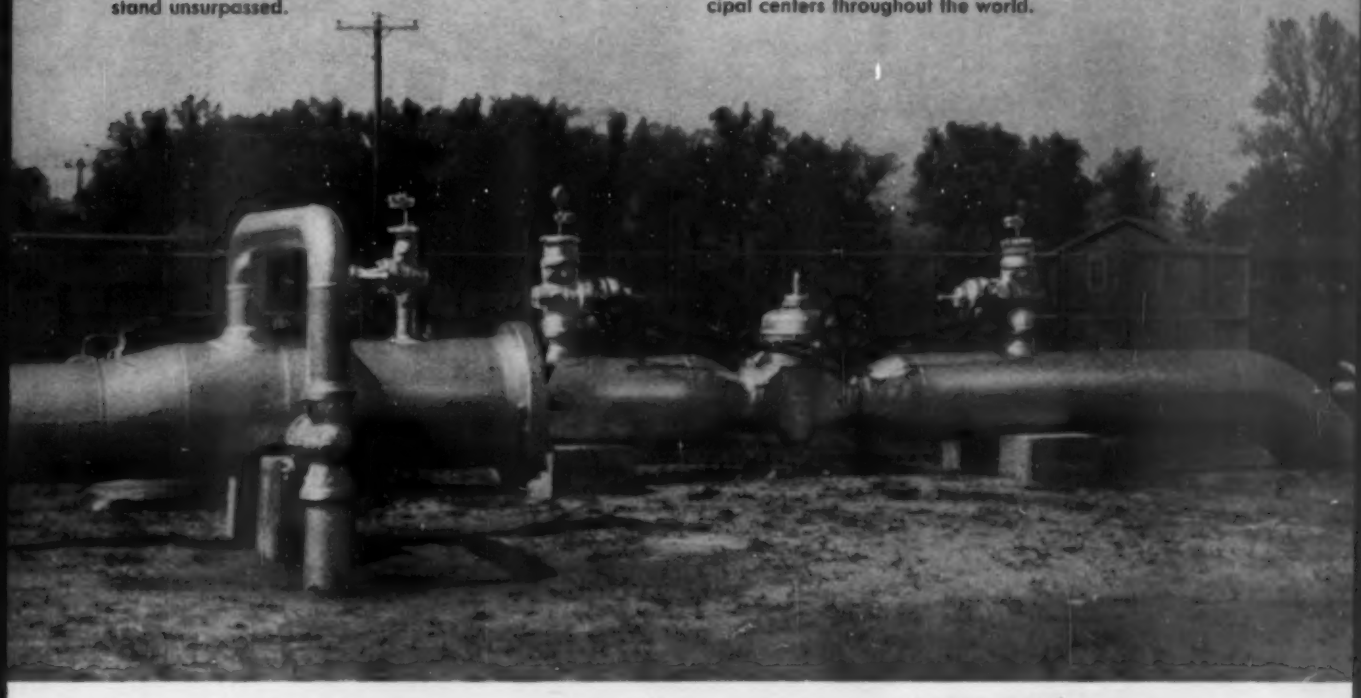
Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.
REPRESENTATIVES AND LICENSEES:
Brazil • Canada • England • France • Italy • Netherlands • Scotland • Venezuela

MAJOR PIPELINES EVERYWHERE

are served better by the very best . . . Walworth Lubricated Plug Valves

Walworth Cast Steel Lubricated Plug Valves enjoy a long record of successful service on oil and gas pipelines the world over. In design, construction and performance they stand unsurpassed.

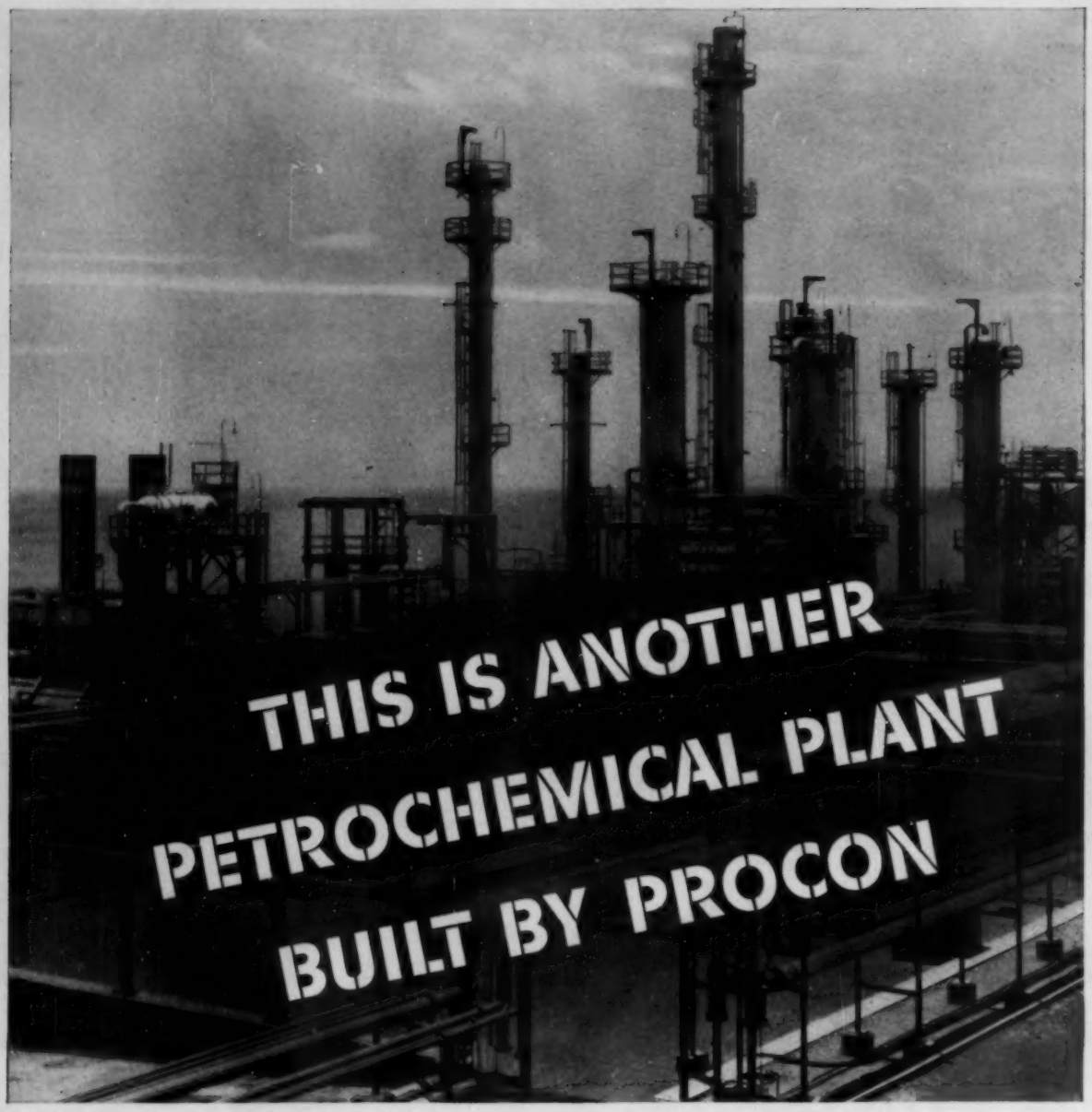
Other Walworth products include Gate, Globe, Angle and Check Valves in a wide range of types and sizes for the oil and gas industries — sold by distributors in principal centers throughout the world.



WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. · CONOFLOW CORPORATION · M & H VALVE & FITTINGS CO. · SOUTHWEST FABRICATING & WELDING CO., INC. · WALWORTH COMPANY OF CANADA, LTD.



This fine plant overseas is just one example of Procon's continually growing accomplishments in petrochemical construction. Like all our projects, it was completed on schedule and up to every specification.

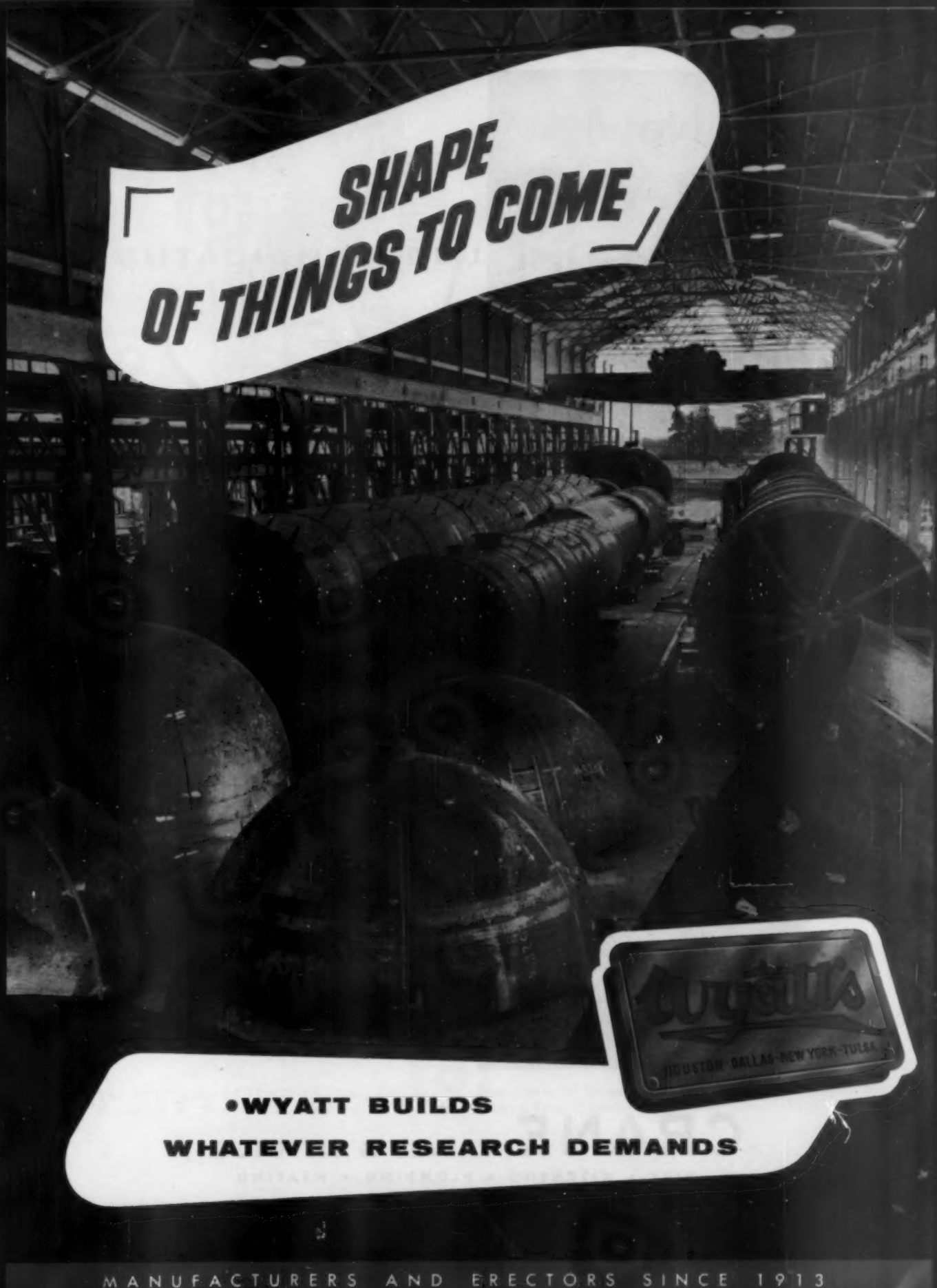
Procon's world-wide construction organization provides a complete service, including new plant construction, additional process facilities, expansion or modernization, to the petrochemical, chemical and oil refining industries. Our services are available to you, any time, anywhere.

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS, U. S. A.

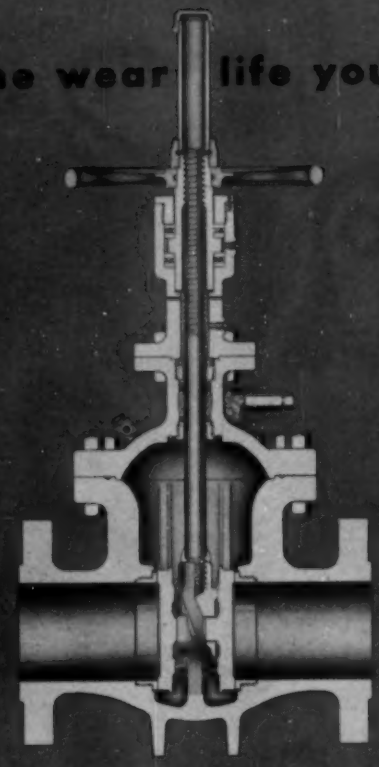
PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND
PROCON INTERNATIONAL S. A., SANTIAGO DE CUBA

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES


SHAPE
OF THINGS TO COME
Augustus
HOUSTON DALLAS-NEW YORK-TULSA
•WYATT BUILDS
WHATEVER RESEARCH DEMANDS
MANUFACTURERS AND ERECTORS SINCE 1913

New CRANE Double-Disc Valve

has the wear life you want on pipeline service



ORDER NOW!

Available in sizes 4 to 24 inches; flanged ends (No. 1680) or butt-welding ends (No. 1681). Either spur or bevel gearing can be provided. For full details, see your local Crane Representative or write to address below.

Developed for both oil and gas transmission, this new Crane gate valve has the long-wear features you want for steady, trouble-free service in your lines.

This new Crane valve design has free-to-rotate double discs—hung independently to change seating position with every operation. Each time this valve is opened or closed, both discs are free to turn to provide cleaning action on seating contact areas, and thus prevent abrasive materials from collecting.

Disc clearances are always accurate, because the two identical discs move up and down in machined body-guide ribs—which take the service abuse usually forced on disc faces in conventional double-disc gate valves, a frequent cause of damage and costly maintenance.

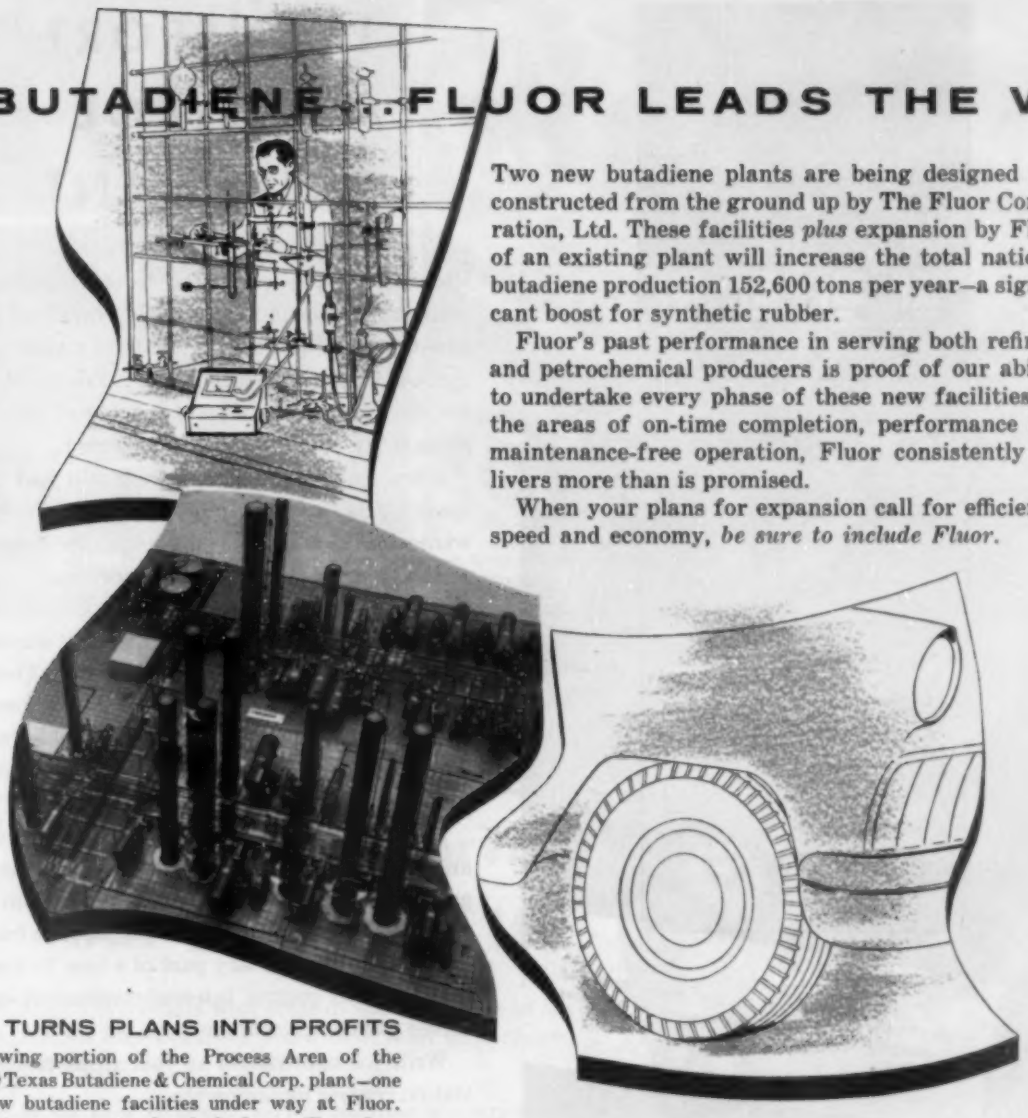
Consider and compare, too, the perfect disc alignment in this smooth-working Crane pipeline valve. Annular-shaped machined wedging surfaces keep both discs and the body ring seat faces lined up at all times—and, in addition, compensate for any slight body deflections caused by line strains.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches & Wholesalers Serving All Areas

IN BUTADIENE . . . FLUOR LEADS THE WAY



Two new butadiene plants are being designed and constructed from the ground up by The Fluor Corporation, Ltd. These facilities *plus* expansion by Fluor of an existing plant will increase the total national butadiene production 152,600 tons per year—a significant boost for synthetic rubber.

Fluor's past performance in serving both refiners and petrochemical producers is proof of our ability to undertake every phase of these new facilities. In the areas of on-time completion, performance and maintenance-free operation, Fluor consistently delivers more than is promised.

When your plans for expansion call for efficiency, speed and economy, *be sure to include Fluor.*

FLUOR TURNS PLANS INTO PROFITS

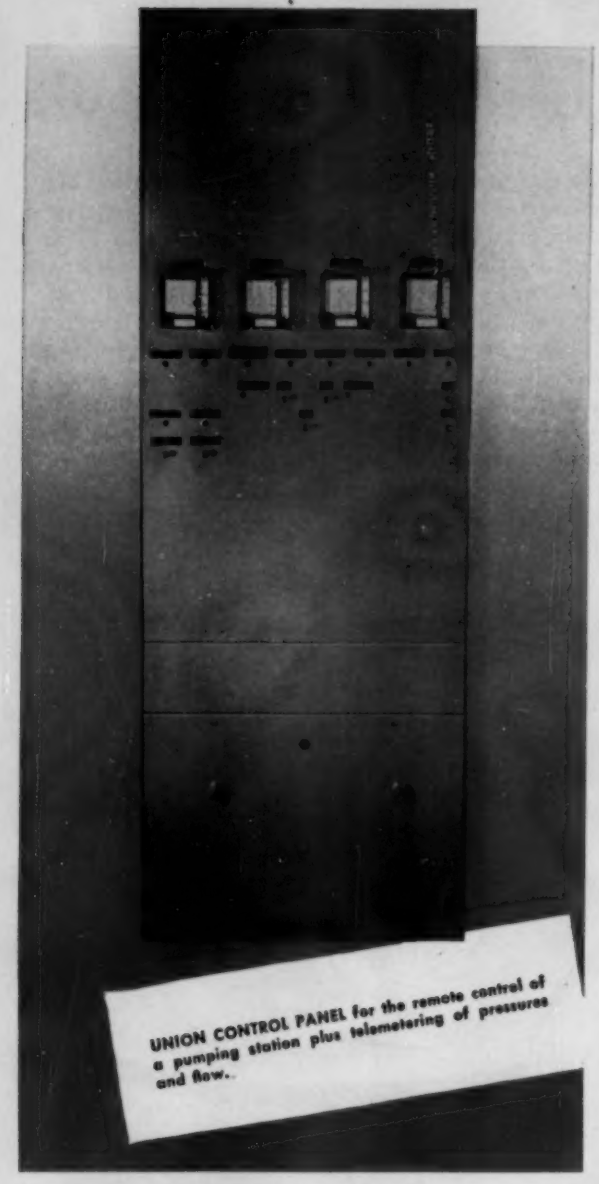
Model showing portion of the Process Area of the $30,000,000 Texas Butadiene & Chemical Corp. plant—one of two new butadiene facilities under way at Fluor. This important new petrochemical plant will produce both butadiene and aviation gasoline.

FLUOR *ENGINEERS and CONSTRUCTORS for the Petroleum, Chemical and Power Industries*

The FLUOR CORPORATION, Ltd., Los Angeles—Mid-Continent Division, Houston—Fluor of Canada, Ltd., Toronto — H. G. Acres & Company, Niagara Falls, Ontario — Singmaster & Breyer, Inc., New York City

QUALITY FIRST . . . TO LAST

IN UNION CENTRALIZED TRANSPORT CONTROL EQUIPMENT



UNION CONTROL PANEL for the remote control of a pumping station plus telemetering of pressures and flow.

Recently we received a letter from a pipeline company that had installed UNION Centralized Transport Control Equipment more than a year ago. At that time, the engineers had ordered duplicate parts for the most vital pieces of equipment just to be prepared in case anything went wrong.

After a year's operation, they still had all the spare parts—*not one had been used!* Now they wanted to know if they could return the spare parts as the equipment was operating perfectly, with no signs of trouble.

This is a good example of the reliable service you can expect from UNION Centralized Transport Control equipment. Every piece of equipment is designed and built to give years of trouble-free life. The relays, which form the heart of the system, are designed for millions of operations!

UNION Centralized Transport Control Systems are now being used on a variety of pipeline layouts, gathering systems, tank farms and off-shore applications. You can control an entire pipeline from one dispatching office or any part of a line. It has even been used to control internal-combustion-engine-driven gas compressor stations.

Write for information on your single or multiple station control requirements.

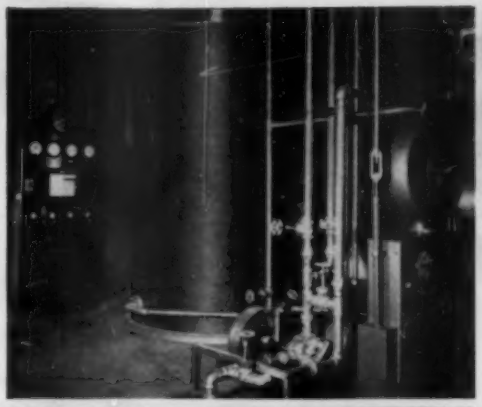
75 Years 1881 1956

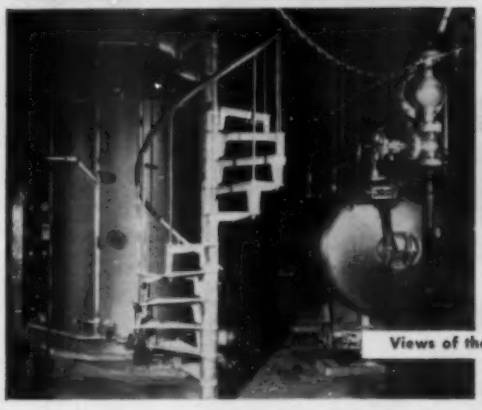
OF EQUIPMENT AND SYSTEMS ENGINEERING . . . . .

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

SWISSVALE, PENNSYLVANIA





Views of the new Visco Anaheim, California plant.

Everything's new but the drum of blue and the *Visco* service that goes with it!

Here Visco points with pride to another source of the famous blue drum—a brand new plant at Anaheim, California.

In the field, of course, no one has time to worry about where a product comes from, just so it does a job effectively, economically—*and is always available.*

That's Visco without a doubt, and our new Anaheim plant with all its modern equipment and instrumentation is just a further assurance that Visco quality and service will never let you down.

VISCO PRODUCTS COMPANY
INCORPORATED
Telephone: MAdison 3-0433
2600 Nottingham at Kirby • Houston 5, Texas
PLANTS AT ANAHEIM, CALIFORNIA and SUGAR LAND, TEXAS

Visco® **CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS**

40 BELOW

A D6 BUILDS A ROAD, PREPARES A SITE

AND 4 FEET OF SNOW

R. N. Robinson, Hayden, Colo., prepared a site for the Texas Company 12 miles west of Steamboat Springs. Elevation was 8000 feet, temperatures dipped to 40 below and four feet of snow were on the ground. He picked a CAT* D6 Tractor to build an access road, dig pits and excavate for foundation footings.

"I know the record of Cat-built equipment in cold, mountain country," he explained. "My Cat Diesel Tractors always have been reliable. They run longer and cost less than any other tractor."

The D6, like all Caterpillar-built equipment, is designed for hard and heavy service in oil patches around the world—whether in arctic or tropical climates. The great new oil clutch is an example. Not only does it add dependability, but it reduces service and maintenance costs. Clutch adjustments are rarely needed. Disc replacements are required no more frequently than engine overhauls.

You'll never run out of jobs for these work horses. They clear brush, level sites, build roads, dig and fill pits, dig gathering line trenches, dike storage tank areas and level finished well sites. From site preparation to cleaning up, they are your most versatile machines.

And no matter what the footing, you'll find these machines have the sure traction and power to do all these jobs quickly and inexpensively.

Your nearby Caterpillar Dealer has the exact units you require. And he'll demonstrate any of his profit-making equipment on *your* job . . . at *your* convenience. See him soon.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

NAME THE DATE . . .
YOUR DEALER
WILL DEMONSTRATE

Amazing progress in industry and business has created such a demand for higher technological skills that shortage of trained manpower is threatening to bottleneck further advance. Here are some of the facts . . . . . .

HELP WANTED: Scientists Engineers

Dr. Alan T. Waterman

Our national problem of "manpower in the jet age" has two major aspects. The first is: How can we as a nation fulfill our continuing objective of providing our young people opportunity for education up to their highest skills and talents? and, second: How can we meet the immediate as well as the long-term problem of providing adequate numbers of scientists and engineers in an age of rapid technological progress?

The second aspect of the problem, in particular, is by no means exclusively our own: the world is experiencing a technological revolution; and although it may be in different stages in various countries, most nations are keenly aware of it and are making an all-out effort to increase their numbers of scientists and engineers. We are constantly warned that the Soviet Union threatens to outstrip us in the numbers of technically trained people it produces, and we cannot afford to ignore the implications of this possibility.

But the race for technical achievement is by no means limited to the United States and the USSR. Furthermore, we must bear in mind that our objectives may be different in important respects from those of other nations, so that it is first of all important to look at the problem squarely in terms of our own national needs and goals.

Only last month, the Department of Commerce announced that the gross national product has for the second time passed the $400 billion mark. President Eisenhower has confidently predicted that within the next 10 years the $500 billion level will be reached. Obviously science and technology have played an important part in this tremendous economic advance. Much of our research and development effort is concentrated in industry.

Results of a recent survey of science and engineering in American industry, soon to be published by the National Science Foundation, indicates that private industry performs about two-thirds of all research and development in the natural and engineering sciences conducted in the United States. In the survey year, 1953, industry's research and development activities, including government contracts, cost approximately $3.7 billion out of a total of more than $5 billion. It follows, therefore, that the majority of all the nation's scientists and engineers are employed by industry.

Of 250,000 scientists and 700,000 engineers more than 60 per cent of the scientists are in industry, with the remainder divided equally between education and government. Seventy-five per cent of the engineers are in industry, only 2 per cent in education, and the remaining 23 per cent in government. Only about one-third of all the scientists and engineers employed in industry are engaged in research and development.

As a nation, we must be concerned that the needs of all three consumers of technical skills—industry, education, and government—are equally met. Our economic strength as well as our military strength depend upon it, and clearly both are involved in our national security. The problem we are facing today is: "What can we do to assure a continuing supply of these vital skills and to prepare to meet the needs of the future?"

We know that we must provide a good educational system with competent instruction in science and mathematics, beginning with the secondary school and going straight through graduate school.

We realize that there must be adequate support and encouragement of basic research as the source of new knowledge and technological breakthroughs, but also because basic research is the only means whereby talented young scientists can acquire the training that they must have if they are to become truly creative in their fields.

We know these things quite well, and so the real question becomes: "What are we doing about them?" Perhaps it may be useful to examine briefly the present situation.

A great deal is said about critical shortages of scientists and engineers, but not enough that is specific and therefore helpful. A really accurate statement is that there are critical shortages in some, but not in all, fields, and that there is a constant demand for highly qualified personnel in all the

*Director, National Science Foundation, Washington, D. C. This article taken from a speech before the Annual Airpower Symposium, New Orleans, Louisiana, August 2, 1956.

fields of science and engineering.

The Foundation went into the manpower situation in considerable detail in the industrial survey by interviewing officials of 200 selected companies which together accounted for more than two-thirds of the 1953 cost of research and development performed by private industry. These companies employed more than **half of the number of research and development scientists and engineers on company payrolls.** It was found that at least **half of the companies** reported that they **were unable to hire enough research scientists and engineers to meet their needs;** one out of every three reported major or substantial shortages of such personnel. Companies which reported they had been able to fill their requirements for research personnel emphasized their need for "better qualified" applicants.

The need for personnel seemed to be most widespread among aircraft, electrical companies, petroleum, paper, food, and primary metal companies.

From other sources come further indication as to the nature and extent of the shortages. Mathematicians, for example, are high on the list of shortages, and a report has recently reached us that one aircraft company is paying a "bounty" of $100 a head for every mathematician recruited by an employee!

In 1953, International Business Machines estimated that at least 1500 applied mathematicians would be required to man computers that were already installed or were on order. This year, IBM estimates that **7500 mathematicians will be needed to man computers on order,** of whom **about 1500 should be Ph.D.'s.**

How does this compare with output? **About 250 Ph.D.'s** in mathematics, or **about one-sixth of the estimated need for computers,** will be graduated this year; and the worst of it is, as our program director for mathematics puts it, *"All but a few of these 250 don't know a computer from an eggbeater."*

This is only one of a number of areas where trained mathematicians are urgently needed. Physics is another field in which the shortage is conspicuous. The trend in the employment of physicists has been an interesting phenomenon. Fifteen years ago the majority of physicists were engaged in research and teaching in our universities. Today, over half of them are employed by industry.

The Placement Register, sponsored by the American Institute of Physics at its annual meeting in New York last winter, reported that more than 200 recruiting organizations offered over 2000 jobs. Of the total number of 308 applicants for jobs, 57 were students, and eight were unemployed, or a total of 65 applicants who could be employed without creating additional vacancies!

The most publicized field of shortages is, of course, engineering. As the result of a recent special survey of 414 industrial and governmental organizations, the Engineers Joint Council finds a rise in demand for engineering graduates in 1955 and 1956 substantially above that in any year since 1951.

After cautiously balancing the number of complex factors involved, the Council concludes *"... the data would seem to warrant the assertion that the situation would be considerably eased if the total number of engineering graduates this year were of an order of magnitude between 35,000 and 40,000."* Our own estimates indicate engineering graduates for 1956 to be of the order of 30,000.

It will be apparent to all but the very short-sighted that there must be a general effort to increase the supply at the source by encouraging more able young people to go to college and by strengthening the material rewards as well as the prestige of teaching in the high schools where the important ground work for future training is obtained.

Industry must face up to the fact that in trying to fill immediate vacancies, raiding not only the colleges and universities but the secondary schools of their math and science teachers will create far greater problems for the future.

Industry can and is helping the teaching situation in many constructive ways, and these efforts should be expanded. A number of industrial research laboratories offer summer jobs for teachers which not only help their chronically low financial condition but also bring them into contact with new developments in science and engineering. Industrial support of summer institutes for high school and college teachers of science and fellowships for teachers are other useful ways in which to help.

The need is so great that the responsibility must be shared by government, industry, private foundations, and other groups. Recent action by seven university presidents in setting forth guiding principles for industrial gifts offers a useful pattern by which corporation gifts to academic institutions can achieve the maximum benefits.

The appointment, by President Eisenhower, of the National Committee for the Development of Scientists and Engineers provides a forum as well as an action group through which many ideas for meeting the needs for scientists and engineers can be explored.

The Committee, which is headed by Dr. Harold L. Bevis, president of Ohio State University, met for the first time in May of this year and has proceeded to organize a series of working groups to consider the long-range, as well as immediate, aspects of the problem. At its first meeting, the Committee agreed that although

> **... some rather obvious first steps could be taken to bring relatively quick results, the basic solution of the problem was a long-range one. The Committee further agreed that the solution could only come by creating local as well as national conditions which would attract a greater number of our more gifted youth to the fields of science and engineering; making those adjustments in our educational system which are necessary if we are to improve the quality of science and engineering training; and those adjustments in the industrial system which will improve the utilization of our scientific and technological manpower.**

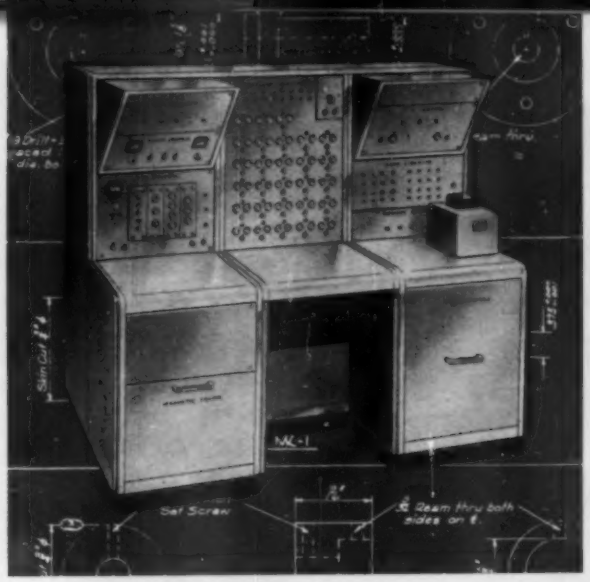
One hopeful note in the whole situation is the growing awareness everywhere of the need for decisive action if our society is to produce the scientists and engineers it requires in order to maintain itself. Whenever people become thoroughly conscious of a need to be met, or a job to be done, they generally roll up their sleeves and do something about it.

We can expect, I think, that a great deal of good will ultimately result from the critical aspects of the present situation, because in order to train enough scientists and engineers, we must first strengthen our whole educational system and provide much stronger incentives for good teachers. These are things that we should be doing, regardless of the special needs in certain fields.

Finally, there is a positive side to the whole matter which has been excellently stated in the Interim Report of the Joint Committee on Atomic Energy's Subcommittee on Research and Development. Commenting on the shortage of scientific and engineering manpower, the report notes:

> **It is important to recognize at the outset that these serious shortages are not a sign of failure but an indication of startling success. A way of life has been created in which the demands made for superior skills in every field have become so tremendous that growth and expansion have become constant elements of the normal pattern. A society has been created in which progress is not simply a matter of occasional spurts and short-term crises. Rapid progress has become a normal part of our national life, and the skilled manpower to keep up with this steadily and rapidly advancing march of progress will be in demand for years to come.**

* * *



At left is production model of a seismic magnetic automatic computer. Above is three-unit magnetic drum data processing unit.

Electronics in Action

ELECTRONIC computers are proving their worth in Cities Service as the work horses in the field of accounting and engineering.

All divisions now are gearing their operations toward the fullest utilization of the large magnetic drum computer which will be delivered to the Bartlesville office early next year.

The addition of this large processing unit to equipment already in use opens new avenues of operational research and economy.

Data obtained from this big bertha of the brains will be used by production engineers in determining optimum producing techniques, by civil engineers in sizing oil and gas gathering systems, by process engineers in answering questions on equipment design and in their research into the field of optimum natural gasoline plant and refinery operations. Pipe line dispatchers will use the big computer in solving intricate scheduling programs.

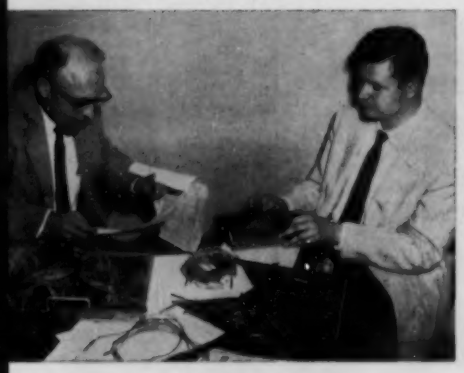
Electronic computers are merely super slide rules or desk computers, combining the practical aspects of a filing cabinet

Editor's Note: This is reprinted from The Empire, Cities Service Oil Company magazine, for June, 1956, John Steiger, editor.

Plant efficiency on the double is possible through the use of electronic computations in gasoline plant balancing. As Engineers Bill Templeton and Wayne Fling are doing it here, it took three days. By electronic calculations, it takes only five minutes.

The new mathematical technique of linear programming of refining operations is being explained by Refineryman Dick Shea, lower left. Through advanced electronics, this new technique opens new avenues of approaching optimum unit operation. Refinery simulation also is a possibility—the coordinated approach toward overall refinery optimum operation.

This is the panel board of the new magnetic drum data processing unit Cities Service will receive early next year. The three-unit machine (pictured directly above) has up to 20,000 memory positions and weighs 2.5 tons.



The Bartlesville electronic calculator was used in sizing the gas gathering system for the Roberts Ranch Gasoline Plant. Engineers Terry Robertson and John Abernathy prepare an instructions panel that will be used in the engineering calculations.

Supervisor Jack Williams checks progress on the gathering system project as the small calculator whisks out the computations that will be used in approaching the sizing of the new gathering system.

In the span of a few hours, the small computer has turned out a group of computations that would have taken weeks to grind out on manually-operated computers. Frank Finfrock of Gasoline and Civil Engineer Art Haas interpret the findings into a complex gathering system that will serve the sprawling Roberts Ranch field of West Texas.

Studying seismic recordings which await computer analyzers when the new machine shown in head is completed.

. . . electronic accounting machine makes quick work of payroll and royalty checks.

In Bartlesville, the Machine Accounting Section handles personnel records, payroll preparation and oil accounting, plus kindred reports. At left, Bob Brians prepares an instruction panel in preparation for issuance of royalty checks.

After the payroll or royalty checks have been written, the machine shown above trims and bursts them and, at the same time, signs them. After this process, they're ready to be placed in windowed envelopes for mailing or for distribution to payroll points.

The electronic and electro-mechanical machines make fast work of such big-time jobs as payroll and royalty payment checks. The instructional panel Bob Brians has prepared has been set in this machine and it's ready to do the job in a few hours. These machines are scheduled for special studies and reports between regular runs.

If you're an employee of Cities Service or own royalty on a Cities Service producing lease, there's a card in these stacks for you — a card punched full of holes. Each of those holes means something and was put there by a group of key punch operators who seldom make a mistake in their punch work.

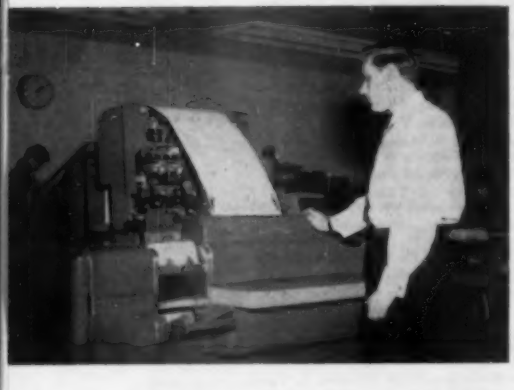
for storage of knowledge, sensing elements for grasping physical conditions and a keyboard catalog for recording all types of arithmetical units.

Electronic computers can't produce miracles. However, they can produce in hours what manually would take days and weeks. Their calculations provide the basis for more efficient and sensitive operations and free the engineer for more productive and creative work. ★ ★ ★

♦ Expansion in the field of electronic tabulation in the Marketing Division has resulted in greater speed, flexibility and accuracy. In the Chicago Region, the wholesale billing operation has been transferred to tabulating.

Punched full of holes, the cards are then ready for the electronic calculator for checking and extension. Terry Krall, operator, is shown just in front of the punching unit. The new calculator is to the left.

Tabulating Supervisor John Harold and Krall are shown preparing wholesale invoices from cards that have come from the electronic calculator.



♦ Billing of National Charge Card customers is done on the 403 accounting machine with a bill feed attachment. R. C. Lawson of Kansas City Marketing is operating.

♦ Vincent Crowley of Kansas City Marketing office prepares age analysis on each customer in the cycle just billed. This analysis gives a history of the account from current to 120 days or more past due.

♦ Just before the monthly bill is mailed to each credit card customer, invoices and statements are microfilmed to provide a thorough history and permanent record of all the activity in the credit card system. George Bisek of Marketing's St. Paul regional office feeds credit material through the microfilming equipment.

♦ Dealer sales reports in Marketing prepared on the electronic accounting machine to give dealer name, address, current-month sales, period-to-date sales and increase or decrease over last year. Kenneth Neiger of the Cleveland Region Marketing office makes a tabulated run on dealer sales for his region.

Instruments and Control Equipment Directory

for the Petroleum Industry

Speed of progress in automation has increased more within the last year, than in all the past. When we wrote "Action in Automation" a year ago you could hardly find the subject in any reference book. Now columns are devoted to automation and to its effect on our economic system and on human relations.

THE PETROLEUM ENGINEER initiated this directory in 1955. This page contains a list of all the leading manufacturers that produce instruments and control equipment used in the petroleum industry. There are more than 100 manufacturers, 25 per cent more than last year.

In the pages that follow instruments and control equipment are listed under three branches of the industry, (1) Exploration, Drilling, Production; (2) Refining and Processing; (3) Oil & Gas Pipelining. Under each piece of equipment are the names of companies that manufacture that particular item.

Every oil and gas company today is interested in the possibility of greater automation. This directory will prove valuable to those who need a quick reference of instruments for specific operations.

This is another unique service feature of THE PETROLEUM ENGINEER.

Manufacturers of instruments and control equipment used in petroleum operations

A-1 Bit & Tool Co., Inc., 9000 Almeda Rd., Houston, Texas
Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.
American Machine & Metals, Inc., U.S. Gauge Div., Sellersville, Pa.
American Meter Co., 1513 Race St., Philadelphia 2, Pa.
Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.
Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.
Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio
Barksdale Valves, Pressure Switch Div., 5125 Alcoa Ave., Los Angeles 58, Calif.
Baroid Div., National Lead Co., 2404 Danville Rd., Houston, Texas
Barton Instrument Corp., 580 Monterey Pass Rd., Monterey Park, Calif.
Beckman Instruments, Inc., Beckman Div., Fullerton, Calif.
Bendix Aviation, Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.
BJ Electronics, Borg-Warner Corp., 3300 Newport Ave., Santa Ana, Calif.
Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Mo.
Oilfield Equipment Div., 1708 W. Main St., Oklahoma City, Okla.
Controls Div., 15 N. Cincinnati, Tulsa, Okla.
S. R. Bowen Co., 11008 S. Norwalk Blvd., Santa Fe Springs, Calif.
Bristol Company, Waterbury 20, Conn.
Camco Inc., 7010 Ardmore, Houston 21, Texas
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.
Crosby Steam Gage & Valve Co., Ashton Valve Co., 43 Kendrick St., Wrentham, Mass.
Dale Co., 1237 W. 15th St., Long Beach 13, Calif.
Daniel Orifice Fitting Co., Inc., 3352 Union Pacific Ave., Los Angeles, Calif.
Eagle Signal Corp., Moline, Illinois
Eastman Oil Well Survey Co., 1360 Speer Blvd., Denver, Colo.
Electric Auto-Lite Co., Instrument & Gauge Div., Toledo, Ohio
EPSCO, Inc., 588 Commonwealth Ave., Boston 15, Mass.
Falstrom Co., 99 Falstrom Court, Passaic, N. J.
Farris Engineering Corp., Palisades Park, N. J.
Fischer & Porter Co., 860 Warminster Rd., Hatboro, Pa.
Fisher Governor Co., Marshalltown, Iowa
Foster Engineering Co., 835 Lehigh Ave., Union, N. J.
Foxboro Co., Foxboro, Mass.
Gadco Products Inc., 1500 E. Burnett, Long Beach, Calif.
Garrett Oil Tool, Inc., P. O. Box 6115, Houston, Texas
General Controls Co., 801 Allen Ave., Glendale 1, Calif.
General Electric Co., Apparatus Sales Div., 1 River Rd., Schnectady 5, N. Y.
Guiberson Corp., 1000 Forest Ave., Dallas 1, Texas
Halliburton Oil Well Cementing Co., Duncan, Okla.
Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.
Hammel-Dahl Co., Warwick Industrial Park, Providence 5, R. I.
Hays Corp., 742 E. 8th St., Michigan City, Ind.
Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.
Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.
Jerguson Gage & Valve Co., 87 Fellsway, Somerville 45, Mass.
Kay Lab, 5725 Kearney Villa Rd., San Diego 12, Calif.
Kobe, Inc., 3040 E. Slauson Ave., Huntington Park, Calif.
Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.
Librascope Inc., 808 Western Ave., Glendale 1, Calif.
L-K Pump Valve Co., 632-640 N. Edgewood, Houston, Texas
Line Scale Co., 2734 S. High, Oklahoma City, Okla.
Liquidometer Corp., 41-03 36th St., Long Island City, N. Y.
J. E. Lonergan Co., 2nd & Race St., Philadelphia 6, Pa.
Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill.
Manning, Maxwell & Moore, Inc., 250 E. Main St., Stratford, Conn.
Jas. P. Marsh Corp., 3501 Howard St., Skokie, Ill.
Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.
Mason-Neilan Regulator Co., 1204 Adams St., Boston 24, Mass.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio
Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.
Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div.,Wayne & Windrim Aves., Philadelphia 44, Pa.
Neptune Meter Co., 19 W. 50th St., New York 20, N. Y.
Norwood Controls, Unit of Detroit Controls Corp., 934 Washington St., Norwood, Mass.
Oil Metering & Processing Equip. Corp., 4843 Yale St., Houston 18, Texas
Oil Well Supply Div., U. S. Steel Corp., 2001 Lamar St., Dallas, Texas
Otis Pressure Control, Inc., P. O. Box 7206, Dallas, Texas
Palmer Thermometers Inc., 2501 Norwood Ave., Cincinnati, Norwood 12, Ohio
Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.
Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio
Penn Instruments Div., Burgess-Manning Co., 4110 Haverford Ave., Philadelphia 4, Pa.
Perkin-Elmer Corp., Norwalk, Conn.
Permutit Co., 330 W. 42nd St., New York 36, N. Y.
Petroleum Instrument Co., 2200 W. Alabama, Houston, Texas
Radio Corporation of America, Camden 2, N. J.
Raytheon Mfg. Co., 100 River St., Waltham 54, Mass.
Refinery Supply Co., 621 E. 4th St., Tulsa 3, Okla.
2215 McKinney Ave., Houston 3, Texas
Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio
Republic Flow Meters Co., 2240 W. Diversey Ave., Chicago 47, Ill.
Robertshaw Fulton Controls Co., Fielden Instrument Div., 2920 N. 4th St., Philadelphia 33, Pa.
Robinson Orifice Fitting Co., 2830 Lugo St., Los Angeles 23, Calif.
Robinson Orifice Fitting Co. of Texas, P. O. Box 17216, Houston, Texas
Rockwell Register Corp., Instrument Div., 510 S. Lansing Ave., Tulsa 10, Okla.
Rolo Manufacturing Co., P. O. Box 6763, Houston 5, Texas
Schutte and Koerting Co., Cornwells Heights, Bucks County, Pa.
Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.
Shand & Jurs Co., 8th & Carolton Sts., Berkeley 10, Calif.
Sperry-Sun Well Surveying Co., 3118 Blodgett Ave., Houston 4, Texas.
Superior Electric Co., Bristol, Conn.
Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio
Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.
Technical Oil Tool Corp., 1057 N. LaBrea Ave., Los Angeles 38, Calif.
Tracerlab, Inc., 130 High St., Boston 10, Mass.
Trinity Equipment Corp., 472 Westfield Ave., E. Roselle Park, N. J.
U. S. Electrical Motors Inc., Box 2058 Terminal Annex, Los Angeles 54, Calif.
Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.
Vernon Tool Co., Ltd., 1101 Meridian Ave., Alhambra, Calif.
Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.
Electro Rust-Proofing Corp., 30 Main St., Belleville 9, N. J.
West Instrument Corp , 4363 W. Montrose Ave., Chicago 41, Ill.
Weston Electrical Instrument Corp., Newark 5, N. J.
Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.
Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.

Chemical Feeders

B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Fischer & Porter Co.
Milton Roy Co.
Permutit Co.
Wallace & Tiernan Inc.

Controllers, and Regulators

Bendix, Pacific Div.
Bristol Co.
Kay Lab
Radio Corp. of America
Raytheon Mfg. Co.

Control Transmission Systems

MECHANICAL

American Meter Co.
Automatic Switch Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fisher Governor Co.
Foster Engineering Co.
General Controls Co.
Guiberson Corp.
Liquidometer Corp.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Mercoid Corp.
Oil Metering & Processing Eqpt.
Otis Pressure Control, Inc.
Penn Instruments
Shands & Jurs Co.
Taylor Instruments Cos.
Vapor Recovery Systems Co.
Weston Electrical Instrument Co.

HYDRAULIC

B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Farris Eng. Corp.
Fisher Governor Co.
Foster Engineering Co.
Gadco Products Inc.
General Controls Co.
Hammel Dahl Co.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Oil Well Supply, Div. U. S. Steel
Parker Appliance Co.
Penn Instruments
Republic Flow Meters Co.
Rolo Manufacturing Co.

PNEUMATIC

American Machine & Metals
American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Farris Eng. Corp.
Fischer & Porter Co.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
General Controls Co.
Guiberson Corp.
Hammel-Dahl Co.
Leeds & Northrup Co.
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Oil Metering & Processing Eqpt.
Penn Instruments
Republic Flow Meters Co.
Robertshaw-Fulton
Rolo Manufacturing Co.
Shands & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
Wallace & Tiernan Inc.
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

Automatic Switch Co.
Barksdale Valves
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Conoflow Corp.
Fischer & Porter Co.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hammarlund Mfg. Co.
Hays Corp.
Hewlett-Packard Co.
Kay Lab
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Reliance & Electric Eng. Co.
Robertshaw-Fulton
Shand & Jurs Co.
Superior Electric Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument
Wheelco Instrument Div.

Flow Controllers

A-1 Bit & Tool Co., Inc.
American Meter Co.
Automatic Switch Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
S. R. Bowen Co.
Bristol Co.
Fisher & Porter Co.
Foxboro Co.
Guiberson Corp.
Hays Corp.
Kobe Inc.
L-K Pump Valve Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Cos.

Flow Meters

DRY TYPE

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Norwood Controls
Oil Metering & Processing Eqpt.
Taylor Instrument Cos.
Penn Instruments

MERCURY U-TUBE

American Meter Co.
Bailey Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument Cos.

SINGLE STREAM

B-I-F Industries, Inc.
Fischer & Porter Co.
Foster Engineering Co.
Foxboro Co.
Neptune Meter Co.
Penn Instruments
Petroleum Instrument Co.

FULL BORE

Fischer & Porter Co.
Foster Engineering Co.
Penn Instruments

ORIFICE

Bailey Meter Co.
Daniel Orifice Fitting Co.
Fischer & Porter Co.
Oil Metering & Processing Eqpt.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas
Rockwell Register Corp.

REMOTE INDICATION AND INTEGRATION

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Librascope, Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Oil Metering & Processing Eqpt.
Penn Instruments
Rockwell Register Corp.
Taylor Instrument Cos.

MASS FLOW

Fischer & Porter Co.
Norwood Controls

Flow Recorders

ELECTRICAL

Bailey Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Manning Maxwell & Moore
Minneapolis-Honeywell
Oil Metering & Processing Eqpt
Penn Instruments
Republic Flow Meters Co.
Rolo Manufacturing Co.
Wheelco Instrument Div.

MECHANICAL

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Dale Co.
Fischer & Porter Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Nepture Meter Co.
Oil Metering & Processing Eqpt.
Penn Instruments
Petroleum Instrument Co.
Taylor Instrument Cos.

Gas Indicators, Analyzers

Bailey Meter Co.
Baroid, National Lead Co.
Bristol Co.
Consolidated Electrodynamics
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances
Permutit Co.
Petroleum Instrument Co.
Wallace & Tiernan Inc.

Intermitter Controls

Black, Sivalls & Bryson, Inc.
Bristol Co.
Camco Inc.
Fisher Governor Co.
Garrett Oil Tools
Guiberson Corp.
Taylor Instrument Cos.

Liquid Level Gages

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Crosby-Ashton
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
Jergueon Gage & Valve Co.
Liquidometer Corp.
Magnetrol, Inc.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Norwood Controls
Panellit, Inc.
Penn Instruments
Petroleum Instrument Co.
Robertshaw-Fulton
Shand & Jurs Co.
Taylor Instrument Cos.
Tracerlab Inc.
Vapor Recovery Systems Co.
Wallace & Tiernan Inc.
Yarnall-Waring Co.

Measurement Equipment

American Meter Co.
Bailey Meter Co.
Bendix, Pacific Div.
Bristol Co.
Eastman Oil Well Survey Co.
Fischer & Porter Co.
Foxboro Co.
General Electric Co.
Halliburton Oil Well
Kay Lab
Oil Metering & Processing Eqpt.
Permutit Co.
Rolo Manufacturing Co.
Taylor Instrument Co.
Technical Oil Tool Co.
Wheelco Instruments Div.

Mud Testing

Baroid, National Lead Co.
Petroleum Instrument Co.

pH-Indicators, Recorders, Controllers

Bailey Meter Co.
Baroid, National Lead Co.
Beckman Instruments
Bristol Co.
Foxboro Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Robertshaw-Fulton
Weston Electrical Instrument
Wheelco Instrument Div.

Pressure Gages

American Machine & Metals
American Meter Co.
Bailey Meter Co.
Bendix, Pacific Div.
B-I-F Industries, Inc.
BJ Electronics
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hayes Corp.
Helicoid Gage Div.
Line Scale Co.
J. E. Lonergan Co.
Manning Maxwell & Moore
Jas. P. Marsh Corp.
Martin-Decker Corp.
Minneapolis-Honeywell
Norwood Controls
Taylor Instrument Cos.
Wallace & Tiernan Inc.

Pressure Recorders

Allegany Instrument Co.
American Machine & Metals
American Meter Co.
Bailey Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Electric Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore
Martin-Decker Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.
Taylor Instrument Cos.
Wallace & Tiernan Inc.
Weston Electrical Instrument

Production Testing Equip.

Black, Sivalls & Bryson, Inc.
Oil Metering & Processing Eqpt.
Rolo Manufacturing Co.

Regulating Units

American Meter Co.
Bailey Meter Co.
B-I F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
General Electric Co.
Guiberson Corp.
Hammel-Dahl Co.
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Taylor Instrument Cos.
Weston Electrical Instrument

Exploration, Drilling, Production Instruments and Control Equipment — Continued

Remote Controllers and Transmission

American Meter Co.
Automatic Switch Co.
Bailey Meter Co.
Beckman Instruments
Bendix, Pacific Div.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fischer & Porter Co.
Fischer Governor Co.
Foxboro Co. ,
Garrett Oil Tools
General Electric Co.
Guiberson Corp.
Hammarlund Mfg. Co.
Leeds & Northrup Co.
Manning, Maxwell & Moore
Mason-Neilan Regulator Co.
Mine Safety Appliance Co.
Minneapolis-Honeywell
Penn Instruments
Permutit Co.
Reliance & Electric Eng Co.
Republic Flow Meters Co.
Robertshaw-Fulton
Servo Corp.
Shand & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.

Safety Heads

Black, Sivalls & Bryson

Safety Valves

A-1 Bit & Tool Co.
Automatic Switch Co.
Farris Eng. Corp.
J. E. Lonergan Co.
Manning, Maxwell & Moore
Otis Pressure Control, Inc.
Shand & Jurs Co.

Speed Controllers

Bristol Co.
Farris Eng. Corp.
Foxboro Co.
Martin-Decker Corp.
Taylor Instrument Cos.

Tachometers

Bailey Meter Co.
Bristol Co.
Foxboro Co.
General Electric Co.
Hewlett-Packard Co.
Martin-Decker Corp.
Taylor Instrument Cos.

Tank Gages

Bendix, Pacific Div.
Bristol Co.
Fischer & Porter Co.
Liquidometer Corp.
Manning Maxwell & Moore
Meriam Instrument Co.
Petroleum Instrument Co.
Shand & Jurs Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

Telemetering

Bendix, Pacific Div.
Kay Lab
Servo Corp.
Shands & Jurs Co.

Temperature Gages, Recorders

Allegany Instrument Co.
American Machine & Metals
Bailey Meter Co.
Beckman Instruments
Bendix, Pacific Div.
Bristol Co.
Dale Co.
Electric Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Hays Corp.
Leeds & Northrup Co.
Manning Maxwell & Moore
Jas P. Marsh Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Palmer Thermometers, Inc.
Penn Instruments
Robertshaw-Fulton
Servo Corp.
Shand & Jurs Co.
Trinity Equipment Corp.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
West Instrument Corp.
Weston Electrical Instrument
Wheelco Instruments Div.

Torque Gages—Recording

General Electric Co.
Martin-Decker Corp.

Weight Indicators and Torque Gages

Allegany Instrument Co.
Bristol Co.
General Electric Co.
Line Scale Co.
Martin-Decker Corp.
Minneapolis-Honeywell
Taylor Instrument Cos.

Well Logging Units

Baroid, National Lead Co.
Bendix, Pacific Div.
Eastman Oil Well Survey Co.
Petroleum Instrument Co.
Tracerlab Inc.

Well Surveying Instruments

Eastman Oil Well Survey Co.
Petroleum Instrument Co.
Sperry-Sun Well Surveying Co.
Technical Oil Tool Corp.
Tracerlab Inc.

Instruments and Control Equipment Used in REFINING and PROCESSING

Analytical Control Instruments

Beckman Instruments
Bristol Co.
Consolidated Electrodynamics
Mine Safety Appliance Co.
Tracerlab Inc.

Boiler Control

Automatic Switch Co.
Bailey Meter Co.
Black, Sivalls & Bryson
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Hays Corp.
Leeds & Northrup Co.
Magnetrol Inc.
Mercoid Corp.
Minneapolis-Honeywell
Republic Flow Meters Co.
Taylor Instrument Cos.
Weston Electrical Instrument
Wheelco Instruments Div.

Boiler Water-Level Indicators

MECHANICAL

Bailey Meter Co.
Black, Sivalls & Bryson, Inc.
Fischer & Porter Co.
General Controls Co.
Jerguson Gage & Valve Co.
Magnetrol Inc.
Meriam Instrument Co.
Yarnall-Waring

PNEUMATIC

Bailey Meter Co.
Black, Sivalls & Bryson Inc.
Fischer & Porter Co.
General Controls Co.
Hammel-Dahl Co.

ELECTRIC

Bailey Meter Co.
Bristol Co.
General Controls Co.
Norwood Controls

Chemical Feeders

B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Fischer & Porter Co.
Milton Roy Co.
Permutit Co.
Wallace & Tiernan Inc.

Chemical Pressure Gages

American Machine & Metals
Bristol Co.
Crosby-Ashton
Fischer & Porter Co.
Helicoid Gage Div.
J. E. Lonergan Co.
Manning Maxwell & Moore
Norwood Controls
Taylor Instrument Cos.

Coke Level Indicators

Tracerlab, Inc.

Conductivity—Indicators, Recorders, Controllers

Bailey Meter Co.
Bristol Co.
Foxboro Co.
General Electric Co.
Leeds & Northrup Co.
Minneapolis-Honeywell
Robertshaw-Fulton
Wheelco Instruments Div.

Control Transmission Systems

Bendix, Pacific Div.
Bristol Co.
Kay Lab
Radio Corp. of America
Raytheon Mfg. Co.

Controllers and Regulators

MECHANICAL

American Meter Co.
Automatic Switch Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fisher Governor Co.
Foster Engineering Co.
General Controls Co.
Mason-Neilan Regulator Co.
Mercoid Corp.
Penn Instruments
Shands & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
Weston Electrical Instrument

HYDRAULIC

Black, Sivalls & Bryson, Inc.
Bristol Co.
Farris Eng. Corp.
Foster Engineering Co.
Gadco Products
General Controls Co.
Hammel-Dahl Co.
Mason-Neilan Regulator Co.
Parker Appliance Co.
Penn Instruments
Republic Fow Meters Co.
Shand & Jurs Co.

PNEUMATIC

American Machine & Metals
American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Farris Eng. Corp.
Fischer & Porter Co.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
General Controls Co.
Hammel-Dahl Co.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Robertshaw-Fulton
Shand & Jurs Co.
Taylor Instrument Cos.
U. S. Electrical Motors Inc.
Vapor Recovery Systems Co.
Wallace & Tiernan Inc.
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

Automatic Switch Co.
Barksdale Valves
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Conoflow Corp.
Fischer & Porter Co.
Fisher Governor Co.
Foster Engineering Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hammarlund Mfg. Co.
Hays Corp.
Hewlett Packard Co.
Kay Lab
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Robertshaw-Fulton
Shand & Jurs Co.
Superior Electric Co.
Swartwout Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument
Wheelco Instrumentc Div.

Flow Controllers

American Meter Co.
Automatic Switch Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
L-K Pump Valve Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Schutte & Koerting Co.
Swartwout Co.
Taylor Instrument Cos.

Flow Meters

DRY TYPE

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Taylor Instruments Cos.
Wallace & Tiernan Inc.

MERCURY U-TUBE

American Meter Co.
Bailey Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument Cos.

SINGLE STREAM

Fischer & Porter Co.
Foster Engineering Co.
Penn Instruments
Schutte & Koering Co.

FULL BORE
Fischer & Porter Co.
Foster Engineering Co.
Penn Instruments

PIPE LINE

Orifice
American Meter Co.
Bailey Meter Co.
Barton Instrument
Bristol Co.
Daniel Orifice Fitting Co.
Fischer & Porter Co.
Foxboro Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas
Rockwell Register Corp.
Schutte & Koerting Co.
Swartwout Co.
Taylor Instrument Cos.

Pitot Tube
Barton Instrument Corp.
Bristol Co.
Foxboro Co.
Meriam Instrument Co.
Norwood Controls
Penn Instruments

Venturi
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments

REMOTE INDICATION AND INTEGRATION
Bailey Meter Co.
Barton Instrument Corp.
Bendix, Pacific Div.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hammarlund Mfg. Co.
Hays Corp.
Librascope Inc.
Magnetrol Inc.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Panellit Inc.
Penn Instruments
Republic Flow Meters Co.
Rockwell Register Corp.
Schutte & Koerting Co.
Shand & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.

Flow Recorders

ELECTRICAL
Bailey Meter Co.
B-I F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Schutte & Koerting Co.
Swartwout Co.
Tracerlab, Inc.

MECHANICAL
American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hammarlund Mfg. Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Schutte & Koerting Co.
Taylor Instrument Cos.

Gas Indicators and Analyzers
Bailey Meter Co.
Bristol Co.
Consolidated Electrodynamics
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances Co.
Perkin-Elmer Corp.
Permutit Co.

Liquid Level Gages

CLOSED VESSELS
Bailey Meter Co.
Barton Instrument
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Crosby-Ashton
Fischer & Porter Co.
Foxboro Co.
Jerguson Gage & Valve Co.
Liquidometer Corp.
Magnetrol Inc.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Meriam Instrument
Minneapolis-Honeywell
Panellit, Inc.
Penn Instruments
Republic Flow Meters Co.
Robertshaw-Fulton
Shand & Jurs Co.
Taylor Instrument Cos.
Tracerlab, Inc.
Vapor Recovery Systems
Wallace & Tiernan Inc.
Yarnall-Waring Co.

Instrument and Control Panels and Cubicles
Automatic Switch Co.
Bailey Meter Co.
Bristol Co.
Falstrom Co.
Fischer & Porter Co.
Foxboro Co.
Mercoid Corp.
Panellit, Inc.
Taylor Instrument Co.

Measurement Equipment
Bendix, Pacific Div.
Bristol Co.
Central Scientific Co.
Kay Lab
Permutit Co.
Shand & Jurs Co.

pH—Indicators, Recorders, Controllers
Bailey Meter Co.
Baroid Div., National Lead Co.
Beckman Instruments
Bristol Co.
Foxboro Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Robertshaw-Fulton
Weston Electrical Instrument
Wheelco Instruments Div.

Pressure Gages
American Machine & Metals
American Meter Co.
Bailey Meter Co.
Bendix, Pacific Div.
B-I-F Industries, Inc.
B J Electronics
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hays Corp.
Helicoid Gage Div.
J. E. Lonergan Co.
Manning Maxwell & Moore
Jas. P. Marsh Corp.
Minneapolis-Honeywell
Norwood Controls
Taylor Instrument Cos.
Wallace & Tiernan Inc.

Pressure Recorders
Allegany Instrument Co.
American Machine & Metals
American Meter Co.
Bailey Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Electric Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument Cos.
Weston Electrical Instrument

Program-Process Control
American Machine & Metals
Bailey Meter Co.
Beckman Instruments
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Consolidated Electrodynamics
Eagle Signal Corp.
EPSCO Inc.
Fischer & Porter Co.
Foxboro Co.
Hammarlund Mfg. Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Panellit Inc.
Penn Instruments
Taylor Instrument Cos.
Weston Electrical Instrument
Wheelco Instruments Div.

Process Controls
American Machine & Metals
Automatic Switch Co.
Bailey Meter Co.
Bendix, Pacific Div.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fischer & Porter Co.
Panellit Inc.
Wheelco Instruments Div.

Safety Heads
Black, Sivalls & Bryson, Inc.

Safety Valves
Automatic Switch Co.
Crosby-Ashton
Farris Eng. Corp.
J. E. Lonergan Co.
Manning Maxwell & Moore
Shand & Jurs Co.

Shut-Down Valve
Automatic Switch Co.
Black, Sivalls & Bryson, Inc.
Vernon Tool Co., Ltd.

Stream Blenders
B-I-F Industries, Inc.
Fischer & Porter Co.

Tachometers
Bailey Meter Co.
Bristol Co.
Foxboro Co.
General Electric Co.
Hewlitt-Packard Co.
Martin-Decker Corp.

Tank Gages
Bendix, Pacific Div.
Bristol Co.
Fischer & Porter Co.
Liquidometer Corp.
Manning, Maxwell & Moore
Meriam Instrument Co.
Petroleum Instrument Co.
Shand & Jurs Co.
Vapor Recovery Systems
Weston Electrical Instrument

Telemetering
Bendix, Pacific Div.
Kay Lab
Servo Corp.
Shand & Jurs Co.

Temperature Gages, Recorders
Allegany Instrument Co.
American Machine & Metals
Bailey Meter Co.
Beckman Instruments
Bendix, Pacific Div.
Bristol Co.
Electro Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Jas. P. Marsh Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Palmer Thermometers Inc.
Penn Instruments
Robertshaw-Fulton
Servo Corp.
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument Cos.
Trinity Equipment Corp.
Vapor Recovery Systems
West Instrument Corp.
Weston Electrical Instrument
Wheelco Instruments Div.

Instruments and Control Equipment Used in OIL and GAS PIPELINING

Transmission Systems Control
Bendix, Pacific Div.
Bristol Co.
Kay Lab
Radio Corp. of America
Raytheon Mfg. Co.

Controllers and Regulators

MECHANICAL
American Meter Co.
Automatic Switch Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fisher Governor Co.
Foster Engineering Co.
General Controls Co.
Mason-Neilan Regulator Co.
Mercoid Corp.
Penn Instruments
Shand & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
Weston Electrical Instrument

HYDRAULIC
Black, Sivalls & Bryson, Inc.
Bristol Co.
Farris Eng. Corp.
Foster Engineering Co.
Gadco Products Inc.
General Controls Co.
Hammel Dahl Co.
Mason-Neilan Regulator Co.
Parker Appliance Co.
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.

PNEUMATIC
American Machine & Metals
American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Conoflow Corp.
Farris Eng. Corp.
Fischer Porter Co.
Fisher Governor Co.
Foster Engineering Co.

Foxboro Co.
General Controls Co.
Hammel-Dahl Co.
Leeds & Northrup Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Robertshaw-Fulton
Shand & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
Weston Electrical Instrument

ELECTRONIC AND ELECTRIC

Automatic Switch Co.
Barksdale Valves
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Conoflow Corp.
Fischer & Porter Co.
Foster Engineering Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hammarlund Mfg. Co.
Hays Corp.
Hewlitt-Packard Co.
Kay Lab
Leeds & Northrup Co.
Manning Maxwell & Moore
Minneapolis-Honeywell
Penn Instruments
Reliance Electric & Eng. Co.
Robertshaw-Fulton
Shand & Jurs Co.
Superior Electric Co.
Swartwout Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument
Wheelco Instruments Div.

Flow Controllers

A-1 Bit & Tool Co.
American Meter Co.
Automatic Switch Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
Hays Corp.
L-K Pump Valve Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Swartwout Co.
Taylor Instrument Cos.

Flow Meters

DRY TYPE

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Cos.

MERCURY U-TUBE

American Meter Co.
Bailey Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Mason Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Taylor Instrument Cos.

SINGLE STREAM

B-I-F Industries, Inc.
Fischer & Porter Co.
Foster Engineering Co.
Penn Instruments

FULL BORE

Fischer & Porter Co.
Foster Engineering Co.
Penn Instruments

PIPE LINE

Orifice
American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bristol Co.
Daniel Orifice Fitting Co.
Fischer & Porter Co.
Foxboro Co.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Robinson Orifice Fitting Co.
Robinson Orifice of Texas
Rockwell Register Corp.
Swartwout Co.
Taylor Instrument Cos.

Pitot Tube
Barton Instrument Corp.
Bristol Co.
Foxboro Co.
Meriam Instrument Co.
Norwood Controls
Penn Instruments
Taylor Instruments Cos.

Venturi
Bailey Motor Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Foxboro Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Taylor Instrument Cos.

REMOTE INDICATION AND INTEGRATION

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter
Foxboro Co.
Hammarlund Mfg. Co.
Hays Corp.
Leeds & Northrup Co.
Librascope Inc.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Rockwell Register Corp.
Shand & Jurs Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.

ELECTRICAL

Bailey Meter Co.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Manning Maxwell & Moore
Minneapolis-Honeywell
Penn Instruments
Republic Flow Meters Co.
Swartwout Co.
Wheelco Instruments Div.

MECHANICAL

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
B-I-F Industries, Inc.
Bristol Co.
Fischer & Porter Co.
Foxboro Co.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Penn Instruments
Taylor Instrument Cos.

Liquid Level Gages

American Meter Co.
Bailey Meter Co.
Barton Instrument Corp.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Crosby-Ashton
Fischer & Porter Co.
Foxboro Co.
Jerguson Gage & Valve Co.
Liquidometer Corp.
Magnetrol Inc.
Manning Maxwell & Moore
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Minneapolis-Honeywell
Norwood Controls
Panellit, Inc.
Penn Instruments
Petroleum Instruments Co.
Robertshaw-Fulton
Shand & Jurs Co.
Taylor Instrument Cos.
Tracerlab Inc.
Vapor Recovery Systems Co.
Wallace & Tiernan Inc.
Yarnall-Waring Co.

Gas Indicators and Analyzers

Bailey Meter Co.
Bristol Co.
Central Scientific Co.
Consolidated Electrodynamics
Fischer & Porter Co.
Foxboro Co.
Hays Corp.
Leeds & Northrup Co.
Mine Safety Appliances Co.
Permutit Co.
Petroleum Instrument Co.

Measurement Equipment — soil resistivity

Associated Research Inc.
Bendix, Pacific Div.
Kay Lab
Permutit Co.

Pipe Line Surveying Instruments

Petroleum Instrument Co.
Sperry-Sun Well Surveying

Pressure Gages

American Machine & Metals
American Meter Co.
Bailey Meter Co.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
General Electric Co.
Hays Corp.
J. E. Lonergan Co.
Manning Maxwell & Moore
Jas. P. Marsh Corp.
Minneapolis-Honeywell
Norwood Controls
Taylor Instrument Cos.
Wallace & Tiernan Inc.

Pressure Recorders

Allegany Instrument Co.
American Machine & Metals
American Meter Co.
Bailey Meter Co.
Beckman Instruments
B-I-F Industries, Inc.
Bristol Co.
Consolidated Electrodynamics
Crosby-Ashton
Electric Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Hammel-Dahl Co.
Hays Corp.
Manning Maxwell & Moore Inc.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Penn Instruments
Republic Flow Meters Co.
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument Cos.
Wallace & Tiernan Inc.
Weston Electrical Instrument
Wheelco Instruments Div.

Remote Controllers and Transmission

American Machine & Metals
American Meter Co.
Automatic Switch Co.
Bailey Meter Co.
Bendix, Pacific Div.
B-I-F Industries, Inc.
Black, Sivalls & Bryson, Inc.
Bristol Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
General Electric Co.
Hammarlund Manufacturing Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Mason Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Panellit, Inc.
Penn Instruments
Permutit Co.
Reliance Electric & Eng. Co.
Republic Flow Meters Co.
Robertshaw-Fulton
Servo Corp.
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument Cos.
Vapor Recovery Systems Co.
Wheelco Instruments Div.

Safety Heads

Black, Sivalls & Bryson, Inc.

Stream Blenders

B-I-F Industries, Inc.
Fischer & Porter Co.

Tachometers

Bailey Meter Co.
Bristol Co.
Foxboro Co.
General Electric Co.
Hewlitt-Packard Co.
Martin-Decker Corp.
Taylor Instrument Cos.

Tank Gages

Bendix, Pacific Div.
Bristol Co.
Fischer & Porter Co.
Liquidometer Corp.
Manning Maxwell & Moore
Manning, Maxwell & Moore
Petroleum Instrument Co.
Shand & Jurs Co.
Vapor Recovery Systems Co.
Weston Electrical Instrument

Telemetering

Bendix, Pacific Div.
Kay Lab
Servo Corp.
Shand & Jurs Co.

Temperature Gages, Recorders

Allegany Instrument Co.
American Machine & Metals
Bailey Meter Co.
Beckman Instruments
Bendix, Pacific Div.
B-I-F Industries, Inc.
Bristol Co.
Electric Auto-Lite Co.
Fischer & Porter Co.
Foxboro Co.
General Controls Co.
Leeds & Northrup Co.
Manning Maxwell & Moore
Jas. P. Marsh Corp.
Mason-Neilan Regulator Co.
Minneapolis-Honeywell
Norwood Controls
Palmer Thermometers Inc.
Penn Instruments
Robertshaw-Fulton
Servo Corp.
Shand & Jurs Co.
Swartwout Co.
Taylor Instrument Cos.
Trinity Equipment Co.
Vapor Recovery Systems Co.
West Instrument Corp.
Weston Electrical Instrument
Wheelco Instruments Div.

Thermometers & Hydrometers

Central Scientific
Refinery Supply

ISA Meeting to Draw 30,000

The 11th annual Instrument-Automation Conference and Exhibit to be held September 17-21, 1956, are expected to bring 30,000 persons to New York City. One symposium will be devoted to instrumentation in International Geophysical Year; others include symposiums on control systems, process control, human enigneering, etc.

Once again they've found a use for the proverbial "pig's squeal." By putting waste brine to work, they tripled the efficiency of calcium chloride as a desiccant.

A New Way to Dehydrate Gas

· Robert A. Daugherty

One of the pesky problems that crops up in all three branches of the petroleum industry is dehydration of natural gas. Wherever natural gas is handled—at the wellhead, in the pipe line, or in the processing plant, its water vapor causes difficulties. Removing it is a non-profit operation and more often than not an expensive one. This new method, which has more than tripled the efficiency of calcium chloride as a desiccant, may be the best solution yet.

A new wellhead dehydration unit that has *no moving parts and uses no fuel gas in the dehydration process* has been thoroughly tested in the severe winter temperatures of the San Juan Basin and the Big Piney field in Wyoming. Despite temperatures ranging all the way down to 45 deg below zero, there were no freeze-ups. Aside from the weekly chart changes and inspections, and the recharging of desiccant every 40-120 days, the units were maintenance free.

This dehydrator uses one of the oldest known desiccants, calcium chloride, in a new patented tower design that is producing dew point depressions of 75 to 100F, without fuel-consuming pumps, stills, heat exchangers, or reconcentrating equipment.

Because of new high efficiency contactor trays, *the amount of water removed from the gas runs 3½ to 5 lb of water per pound of calcium chloride, instead of the usual ratio of 1½ to 1.*

The explanation for this high increase in water removal efficiency lies in the tower's ability to utilize the brine formed by the water and $CaCl_2$ as a dehydration agent.

The new dehydrator column is divided into two sections: the upper one-half of the column, or absorber section, has a capacity of four 370-lb drums of a special grade of pelletized anhydrous calcium chloride; and the lower, or reflux section of the column, contains an entirely new (patented) jet-action tray, which can increase the chemical utility about 350 per cent without reconcentration. Accordingly it reduces the cost of dehydration to a new low level.

Operating and Maintenance Cost

Depending on the temperature of the gas flowing from the unitized separator, the chief operating and maintenance cost is that of replacing the $CaCl_2$, which is used at a rate directly proportionate to the amount of water vapor contained in the gas. Naturally, the lower the temperature in the separator, the more water removed from the gas before it is dehydrated, and consequently, less desiccant used.

In last winter's tests on wells operating at 550 lb, the cost of replacing desiccant varied from 67 cents per mmcf of gas at a flowing temperature of 60F to $2.27 per mmcf at 100F.

Operating Principle of the Unit

The gas from the separator passes through the self-circulating trays where it is partially stripped of water vapor by contact with the brine circulating in the trays. It then passes into the upper bed of highly anhydrous $CaCl_2$.

The remaining water vapor is absorbed directly in the calcium chloride bed. This is the source of the brine reflux, and because this brine dripping from the upper bed is highly concentrated **(1.40 sp gr)**, it continuously and automatically maintains the proper concentration of the reflux, eliminating any expensive reconcentration with its subsequent corrosion problems.

The dilute brine leaving the bottom of the column is about 1.15 to 1.20 sp gr, and because of the low cost of the material used, it is considered expendable and run to a nearby drain pit, along with any free water produced by the well.

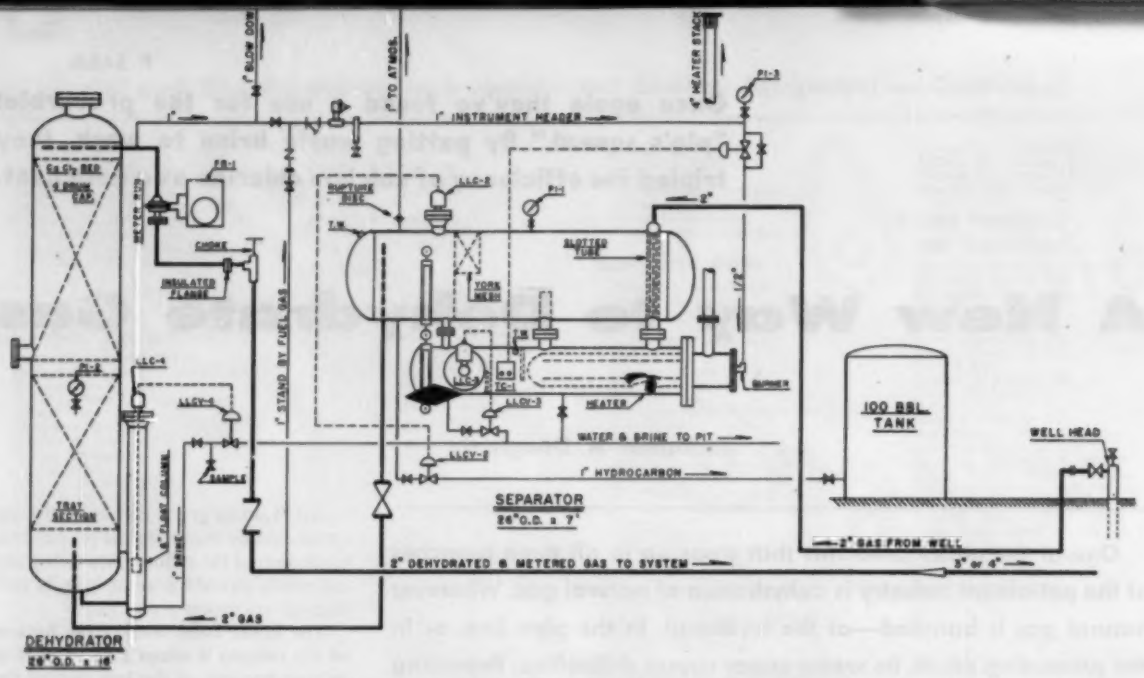
The problem of circulating the brine without circulating pumps was solved by designing a new type of tray which utilizes the flow of gas through a series of jet-action, or gas lift, nozzles, to pick up and recirculate the brine on each tray. The rate of circulation is controlled by a series of weirs and baffles.

Any small amount of hydrocarbon condensation which may take place in the tower is removed by a series of skimmer baffles and directed into the bottom of the tower, and removed from

The Author

Robert A. Daugherty is general manager, manufacturing division, of the Fish Engineering Corporation. He has been associated with Fish ever since 1950, starting as project engineer on gasoline plants and compressor stations, served as project manager of products pipe lines on projects for Phillips Petroleum and Shell-Caribbean in Venezuela. Later he was appointed vice president of Fish Engineering of South America.

Daugherty began in the industry in 1927 as field engineer with The Texas Company, and predecessor companies, in gasoline plants and gathering systems, gas measurement and plant testing. Before joining Fish, he was associated with The Superior Oil Company of California for 20 years. During this time he worked on all phases of oil and gas production and transmission.



Schematic Diagram of the Dehydrator. The horizontal separator contains a mist extractor that removes much of the water and condensates much of the gas before it enters the bottom of the column. The upper half of the column holds about 4 barrels of dry $CaCl_2$ pellets. The bottom half of the tower houses 5 patented trays which utilize the water absorbing characteristics of the brine formed when water vapor comes in contact with the $CaCl_2$. These trays are designed to use the motive power of the gas to reflux the brine as it travels down the column. Specific gravity of the brine coming off the bed is 2.0. By the time the brine reaches the bottom of the column water absorption has cut specific gravity to 1.2.

the column, along with the spent brine, by the liquid level control.

The upper one-half of the tower column is utilized as a storage chamber for the anhydrous calcium chloride. When completely full, it will hold four drums (370-lb each) of $CaCl_2$. As the calcium chloride is used up, forming the brine, the storage column is lowered; *however, the efficiency of the unit is not affected until the level falls to a depth of 24 in.* Normally the dehydrator unit is recharged when three drums of the calcium chloride have been consumed. It is not necessary to remove the calcium chloride left in the unit at the time of recharging. Recharging takes about 15 to 20 minutes.

Normal consumption of chemical at 550 psi operating pressure and various flow temperatures is as follows:

Flowing temp. deg. F	Pounds of $CaCl_2$ per MMCF	Recharging days per MMCF	Chemical cost $ per MMCF
60	9.0#	123	0.6750
70	14.2#	78	1.0692
80	19.7#	56	1.4637
90	25.0#	44	1.8575
100	30.2#	36	2.2713

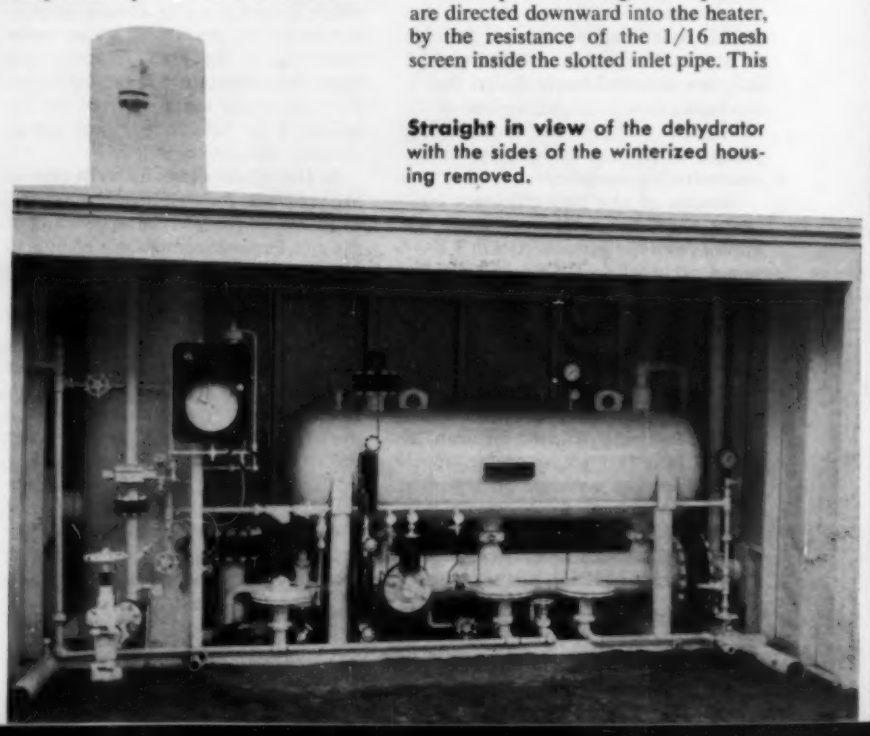
Since the unit consumes calcium chloride in direct proportion to the pounds of water vapor contained in the gas at operating pressure and temperature, the time of recharging the unit can be accurately forecast.

Horizontal Separator

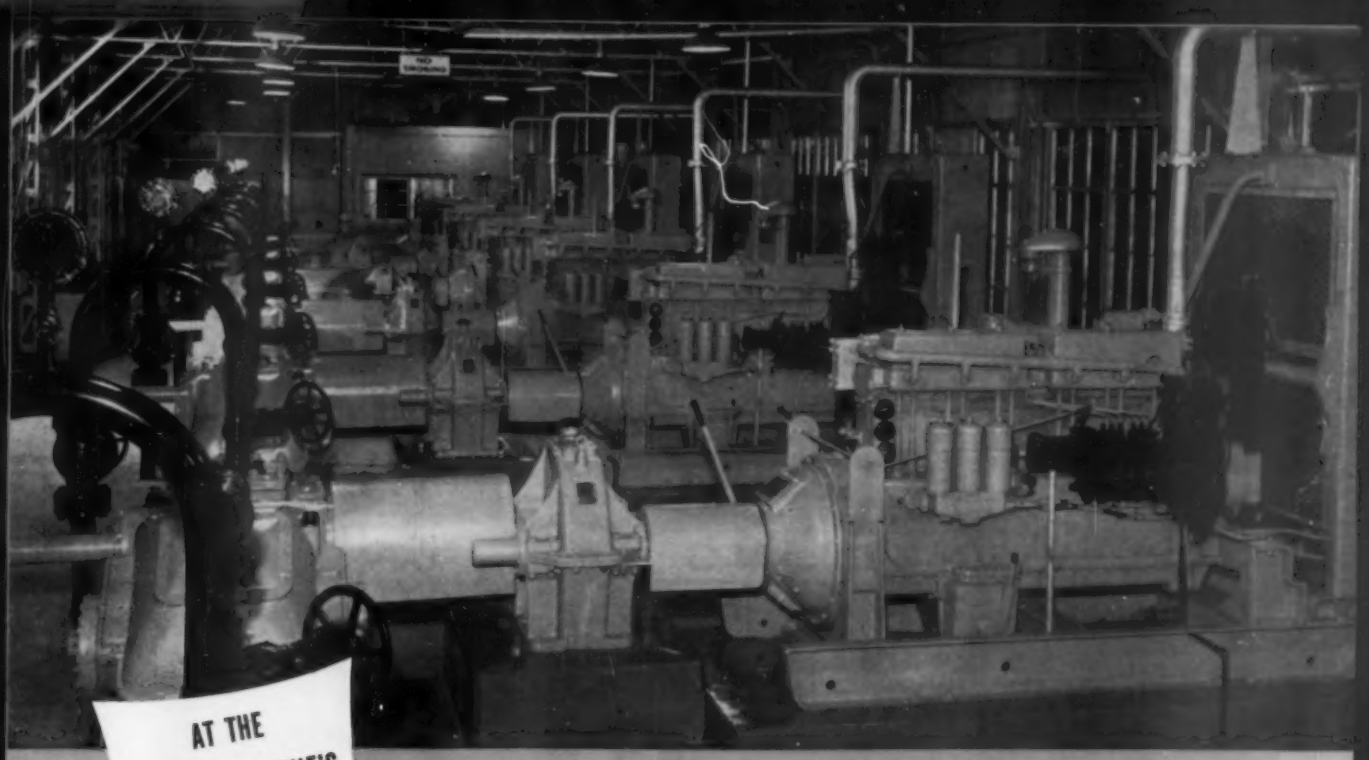
In the past two years of development work and study of field operating problems, it was apparent that a highly efficient separator-heater would be needed for operation in severe low temperature areas. The horizontal separator shown here was designed specifically for this type operation.

An ASME code designed heater is attached to the bottom of the separator with fast-opening flanges for easy removal and cleaning. In normal operation, the heater fires only during low temperature periods to maintain temperature of the water in the separator safely above freezing. The thermostat cuts in the heater at about 50F. Strictly speaking, this heater has nothing to do with the dehydration process. In practice, the heater usually operates when ambient temperatures reach 15F. Under severe winter temperatures, fuel gas for this heater usually runs 2000 to 3000 cu ft per day; however, the heater is of sufficient capacity to successfully handle wells producing emulsions.

The liquids entering the separator are directed downward into the heater, by the resistance of the 1/16 mesh screen inside the slotted inlet pipe. This



Straight in view of the dehydrator with the sides of the winterized housing removed.



AT THE VALLEY PIPE LINE'S COTTONWOOD STATION

THESE CATS* HAVE BEEN PUMPING MORE THAN 18,000 HOURS

THE Valley Pipe Line Company, a subsidiary of The Texas Company, has 14 Caterpillar Engines on its lines delivering oil to tankers at Morro Bay, Calif. Each of the seven D13000s at the Cottonwood Station has more than 18,000 hours on its meter. And at the Emidio Pump Station and other stations in the area, seven more Cat Engines are at work.

These veteran pumping engines are economical because they're built to operate on any kind of fuel that's available, without fouling. Cat Oilfield Engines are flexible, too. For instance, when loads demand more power at any given point, these compact units can be relocated and put in operation in a few hours. It takes only minutes to connect fuel lines and main pump. To give maximum portability, both engine and pump can be mounted on a rigid steel base.

Today the D342 Engine has replaced the D13000 in the Caterpillar line. It's a more powerful 6-cylinder, 4-cycle diesel, honestly rated to deliver 210 HP maximum at 1200 RPM. Built with typical Caterpillar ruggedness and simplicity, the D342 is designed to work for long periods with minimum attention. The fuel system requires no adjustment, reducing your maintenance tasks to a few minutes a month for filter changes.

Your Caterpillar Dealer has a complete line of new engines in a range of sizes up to 650 HP (maximum). He backs them with the best in service and with parts you can trust. And he's as near as your telephone. Call him today.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

MODERN HEAVY-DUTY OILFIELD ENGINES

works especially well when the liquids contain emulsions. Flowing the cold incoming liquid across the heater tube surface makes for better separation of the hydrocarbons and water.

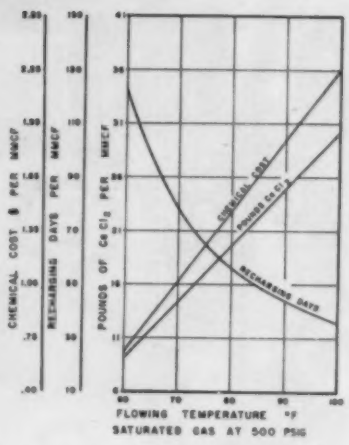
The separator is equipped with a mist extractor element for the final removal of entrained liquids from the gas. The water and hydrocarbon levels in the separator and the spent brine level in the dehydrator are maintained by a new type pneumatic magnetrol that operates snap-acting dump valves. This arrangement has proved exceptionally reliable for unattended field operation.

Protection of Instrumentation and Controls

The entire unit is enclosed in a winterized structure with only the fire box on the separator-heater, the top of the vent stack, and the loading nozzle of the tower exposed to ambient temperatures. The radiation heat from the heater stack, located inside the building, prevents severe temperature drops from affecting the instrumentation, the well meter station, or the $CaCl_2$ brine.

Capacity of the Units

There are four models of the unit in use today: They are:



Cost versus temperature.

Capacity MCF/day	Designed working pressure	Hydrostatic test preasure
2500	990	1500
5000	990	1500
2500	660	1000
5000	660	1000

Unitized Structure

The unit is entirely skid-mounted; all piping, instruments and controls are preassembled and shop-tested. It does not require a foundation on normal bearing soil. The winterizing housing is made of prefabricated, bolted sections, and provided with adequate flashing to seal all openings.

The gas-fired tubular heater can be removed from the outside of the winterized housing simply by unbolting one flange. The heater shell can be separated in minutes by unbolting the quick-opening flanges; as a matter of fact the entire unit can be steamed out, cleaned, and reassembled in two hours.

Because of the simplicity of the unit — its lack of moving parts and low operating and maintenance costs, Pacific Northwest Pipeline Corporation is equipping all of its wells in New Mexico, Colorado and Wyoming with the new units now being manufactured at the Fish plant in Aztec, New Mexico.

Corrosion

All vessels in the unit are designed with code corrosion allowance and since the unit operates at wellhead pressure, this will ordinarily eliminate the presence of free oxygen to promote corrosion. Due to the preferential affinity of the water vapor to the calcium chloride, the distinctive dilute acids formed normally in the presence of H_2S or CO_2 will not be present. Calcium chloride can be used for drying all gases and it does not react chemically with them. ★ ★ ★

WHEELING
COUPLINGS
FOR OIL COUNTRY USE
LINE PIPE COUPLINGS A.P.I.
⅛" to 12" — Seamless — Black or Galvanized
PLAIN TUBING COUPLINGS A.P.I.
1" to 4" — Seamless
EXTERNAL UPSET TUBING COUPLINGS A.P.I.
¾" to 3½" — Seamless
CASING COUPLINGS A.P.I.
4½" to 13⅜" — Seamless — Long or Short
HYDRAULIC COUPLINGS
⅛" to 4" — Seamless
REAMED AND DRIFTED A.I.S.I.
¾" to 12" — Seamless
DRIVE PIPE COUPLINGS
6" to 12" — Seamless or Special Processed
Sales Offices in Leading Cities:
Albany, N. Y.—Albert L. Becker, 434 Clinton Ave.
Baltimore, Md.—William H. Thurlow, 2301 No. Charles St.
Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—Earl H. Jones & Co., 1863 Wazee St.
Detroit, Mich.—R. W. Lang, Jr., 505 Park Avenue
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Grand Rapids, Mich.—R. W. Lang, Jr., 138 Burton SE
Houston, Texas—Henry H. Paris Distributor, Inc., Box 932
Independence, Mo.—Craig A. Fross, 3701 Norwood
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Avenue
Louisville, Ky.—Sid. Schultze Co., 514 W. Main St.
Milwaukee, Wis.—W. G. Nelson, 3347 N. 97th St.
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
Newark, N. J.—Ira L. Rothenberg & Assocs., 398 Market St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
Omaha, Neb.—Wm. Freiden, Central States Engineering & Sales Co., 5101 Blondo St.
Oswego, N. Y.—Northeastern Associates, Inc., Neil Chatterton, Secretary, P. O. Box 284
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Walter C. Dollinger, Dollinger & Lucas, 1047 Big Bend
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.
TOP QUALITY Since 1918
WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

STOP COLOR DEGRADATION in distillate fuels

WITH *Nalco* FUEL OIL TREATMENTS

Pronounced color degradation and sludging tendencies evident in this distillate fuel appeared *after* only 2½ months storage.

Despite extreme instability of the oil, Nalco treatment was effective. Note much lighter color of treated sample . . . same oil, same storage period.

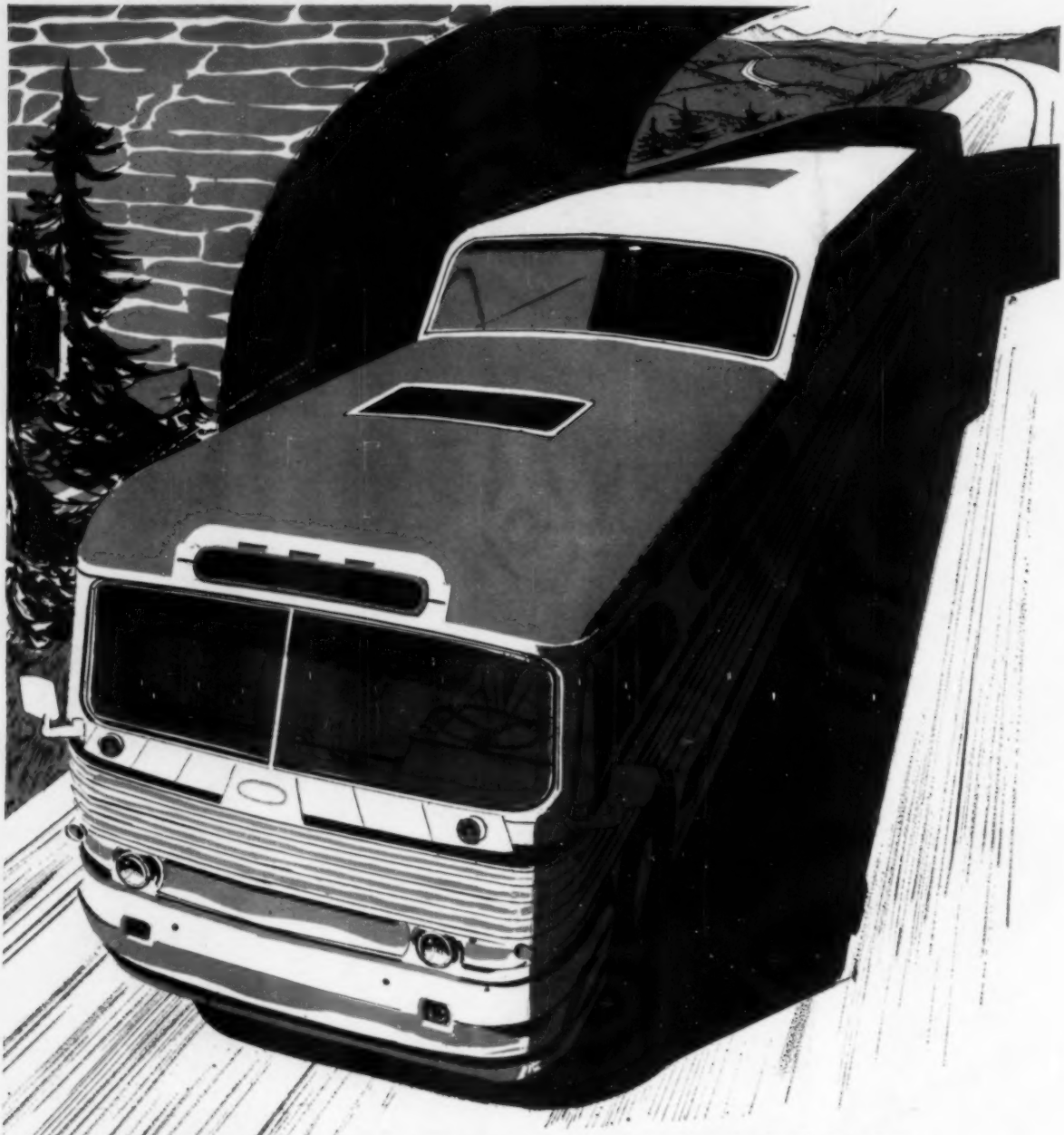
COLOR degradation is a sure profit-cutter in fuel oils . . . but Nalco stabilizing treatment is the low-cost way to *stop* color degradation, keep oils refinery-fresh looking and acting.

Samples illustrated were refined from a highly sour crude; T.C.C. processed. Finished product was very unstable and color degradation occurred quickly in storage. Addition of Nalco treatment has greatly increased stability . . . helped stop both color degradation and sludge formation.

Regardless of your crude charge characteristics or processing methods, you can depend on your Nalco Representative to recommend treatment that will inhibit color degradation and keep your fuel oils at top salability. Write for Technical Data on Nalco Fuel Oil Treatments—or hand us your problem for a prompt, practical solution.

NATIONAL ALUMINATE CORPORATION
6216 West 66th Place • Chicago 38, Illinois
CANADA: *Alchem Limited, Burlington, Ontario*
NORTHWESTERN UNITED STATES, HAWAII AND ALASKA
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: *Nalco Italiana, S.p.A.* SPAIN: *Nalco Espanola, S.A.*
WEST GERMANY: *Deutsche Nalco-Chemi GmbH*

THE *Nalco*® **SYSTEM . . . Serving the Petroleum Industry through Practical Applied Science**

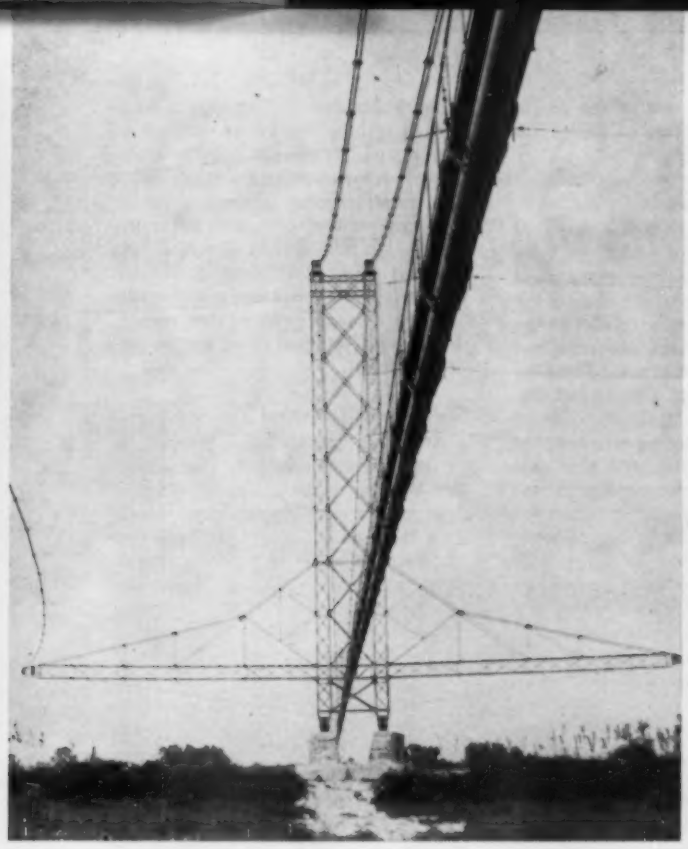


BUS TRANSPORTATION is big business in the U. S. today. Millions of American travelers have found it safe, comfortable, punctual, dependable. Over the years, the men who manage America's bus lines have worked hard to bring their industry to this high degree of efficiency. And we of The Texas Company are proud that so many of them have called on our specialized skills to help them. In fact . . .

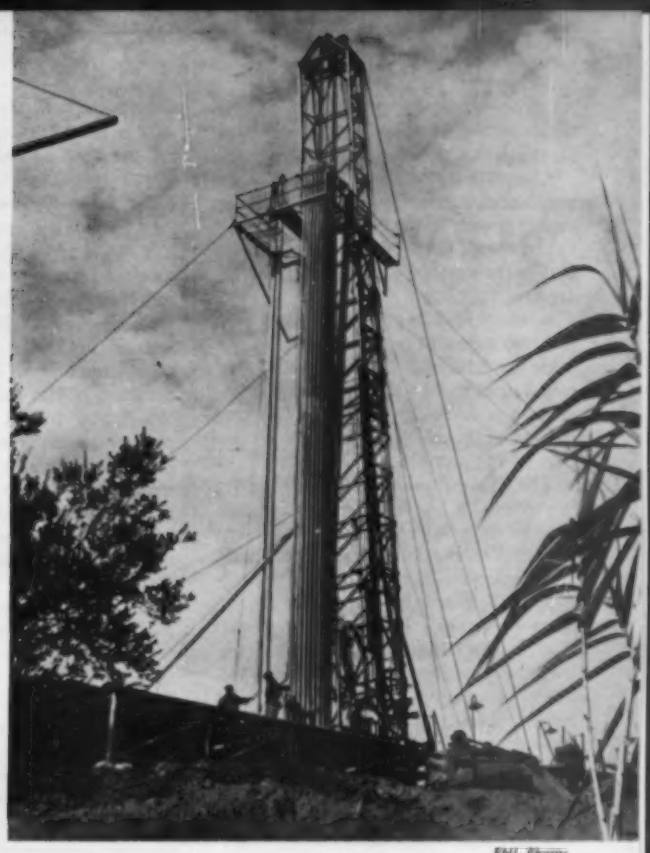
More chassis, wheel bearings, transmissions and differentials of buses in the United States are lubricated with Texaco Products than with any other brand.

TEXACO

THE TEXAS COMPANY



GAS LINE of the state-owned oil and gas monopoly. Here it crosses River Po near Cremona.



ENI Photos

DRILLING AT MADONNA della Croce at Vallacupa, in Abruzzo, a new producing area.

Italian Development Crippled by Laws

New bill being considered by Italian Parliament may not help operations but they could not be much worse than present ones that go back 60 years . . . Sicily offers remarkable contrast

Fernando de Mattia*

In Italy, hot springs, gas and oil products, as well as the so-called "endogenous forces," are subject to mining concessions and are, therefore, ruled by mining laws.

The fundamental law is the 1927 one, later amended. Besides this, there are at present two others, the 1950 Sicilian one on exploration and exploitation of hydrocarbons in Sicily and the one sponsored by the ENI in 1953, through which development in the Padana Valley was restricted to the State agencies.

These three laws enforce the same principle: the subsurface belongs exclusively to the State, the landowner has no authority over any mineral that may be eventually discovered in the subsurface.

The fundamental rulings of the 1927 Law are as follows:

1. Development of mineral substances must be authorized by the State. However, the need of an authorization does not constitute an obstacle for scientific investigations and geological surveys, since permission is only required for actual mining development.

2. Only a deposit of which the State admits the existence and possibility of exploitation is subject to the grant of a concession.

3. A concession may be only granted to a person or company that, according to the judgment of the State agencies, possesses the necessary technical and economic capabilities.

4. Those who have carried out some exploration are preferred (it is a preference, not a right) to other applicants, but if they happen to have sufficient technical and economic capacity, they lose priority in being granted the exploitation concession. They may be granted a premium, however, proportionate to the importance of the discovery made and amount of expense.

*Dr. Mattia, a lawyer, is also an oil consultant and writer in Naples, Italy.

As to operating the concession, limitations are foreseen to guarantee the State against transfers to other bodies.

Also, mortgages are permitted to guarantee creditors, although the rights do not belong to the company, but only to the State. This is an exception justified by the need of guaranteeing mining credits.

Another very important ruling is that in areas adjacent to a known field, the State may call for an overall management, or even take them over. The concession is forfeited when there is any danger of inactivity or inability on the part of the company.

The concession is temporary, but the law does not lay down either limits of time or extension of the areas, leaving it to the State Administration to decide case by case. Thus, the 1927 Law, although inspired by the principle of State ownership, establishes a concession system that, while leaving the ownership of the property to the State, leaves operations to the concession holder as long as he adheres to certain obligations.

Deficiencies have been growing and becoming more serious. It has the merit, however, of unified mining legislation, ruled on in the past by different laws issued in the various Italian States.

Old Laws in Force

The 1927 Law was meant to be followed by regulations that were never issued, so that, even at present, old laws of 1893 and 1899 are still in force, such as the law on mining policy and on prevention of accidents, establishing certain responsibilities of the concessionaire.

After the discovery of the large gas deposits of the Padana Valley, owing to lack of regulations, new exigencies were met through an interpretation process of the 1927 Law. Later a system of making provisions by means of ministerial circulars was followed. The necessity of new and more up-to-date rulings is more than ever felt today because the 1927 Law is neither liberal nor in favor of State ownership, but a juridical absurdity. For instance, it grants exploration permits, but gives no assurance to the oil discoverer that he will be granted the concession.

Finally, the decision has been reached on the basis of mining legislation that would provide a definite arrangement to the petroleum question and coordinate the various interventions and initiatives of the State in this sector. Such a purpose was reached by the 1953 Law, which instituted ENI the sole operator in the Padana Valley.

This last law is based on the "Statist" policy, while the problem of petroleum development in the rest of the peninsula, with the exception of Sicily, has not yet been solved.

New Law Proposed

A plan for a new law was prepared in 1951. Essentially it laid down rules to guarantee the discoverer the right of exploiting his discovery and, at the same time, to set up new rulings on the granting of concessions, including the size of the area to be exploited and the duration of the grant. During last October, the Italian Ministers Council prepared some amendments to the plan in order definitely to settle this controversial question, which has caused in Italy so many debates between the State monopoly and the anti-monopolists, in the petroleum field.

The new bill, already passed by Chamber of Deputies and now being considered by the Senate, gives the State priority over part of the production (from 12.32 to 16.66 per cent), according to the daily production of the wells, besides the participation in the profits, which would give the State royalties about 60 per cent of the gross value of the product, from which the cost of production and naturally, the cost for manpower, must be deducted.

"Trouble in Italian Oil Operations" by Dr. Mattia was published in the May, 1956, issue of *The Petroleum Engineer*. It provides the operational background, which shows how badly needed are practical petroleum laws in Italy.

The adoption of the 60 per cent system in place of the 50-50 system, followed in other countries, is justified by the Italian government argument that operators will not only be working under better conditions than, for instance, those of the Middle East, but will save on transport expenses, and will be able to rely on local absorption of the production.

Among the substantial principles, the following have to be remembered: Reduction of the size of the area in passing from the exploration license to the grant for development; the auction system for the allotment of the areas made available by area reduction or by a concession which is overdue or has been forfeited.

The projected law, leaves ENI as the only concern over the whole area of the Valle Padana, whereas a competitive system will be established in the remaining regions to allow both private concerns and the State to participate in developing promising areas. Opinions on this plan are, naturally, diverse, but this system does combine the principle of State property and private initiative, thus compromising the opposed factions — those for ownership by the State and those for the private citizen.

60% Profit Asked

A further consideration is made by partisans of this new bill. The subsurface belongs to the State, therefore, it may enforce any regulation of operations it chooses. Profits, at a 60 per cent rate are opposed by foreign concerns, with a view to the consequences which eventual approval of such a principal could bring in dealing with other oil nations, where the 50-50 rate is valid. Those favoring the amount say that in reality 60 per cent is only a nominal value, since it fluctuates between 48 and 55 per cent.

In whichever way one wishes to consider the bill, it is most important to solve this question as soon as possible, in order to regulate this section of the Italian economy and open the field to intense oil exploration.

Sicilian Oil Law

To develop the petroleum energy so essential to the economics of the islands, Sicilians prepared a law on hydrocarbons as soon as they obtained their administrative autonomy. Object of this law was to amend the old Italian mining law and attract exploration.

The March 20, 1950 Law No. 50, on oil matters was issued by Sicily within the limits of its administrative autonomy. Although maintaining the concession system at the discretion of the State Administration and the difference between exploration licenses and exploitation concessions, the law follows the free trade system. It allows every one, including foreigners, who have made a discovery, the right of obtaining the exploitation concession.

The maximum area which may be allotted is 100,000 hectares for a period of 20 to 30 years. The percentage of the product which goes to the Region, ranges, normally, from 4 to 20 per cent; however, such a limit is brought up to 10.50 per cent besides all taxes, so that the Region receives, practically, half of the value of the whole product. The rules which govern the oil concessions have been thoroughly studied in order to avoid any kind of monopolization. A strict control over the methods used is maintained so the agent withdraws the oil efficiently. ★ ★ ★

Youngstown's "big 5"

MEAN ELECTRIC WELD LINE PIPE PROVEN AND READY FOR OIL AND GAS PRODUCING AREAS

Here are the "Big 5" reasons why Youngstown Electric Weld Line Pipe is your best buy:

1. It bends readily
2. Wall thickness is uniform
3. Line up characteristics are excellent
4. Weldability is outstanding
5. Long lengths save you time and trouble

In the process of producing Youngstown Electric Weld Line Pipe, every means is explored to assure uniform wall thickness. Uniformity of wall in the pipe begins with control of the skelp thickness produced on the rolling mill. The experience plus control in the rolling of the skelp by men who know steel makes this uniformity possible. Youngstown as an integrated producer has full control over the skelp rolling as well as the finished pipe production. To test the uniformity and quality, the pipe is then placed in a hydrostatic testing machine where internal pressure is applied. To obtain Electric Weld line pipe of uniform wall thickness—specify Youngstown Electric Weld line pipe for your next pipe line job.

Youngstown maintains sales and service offices throughout the oil and gas producing country—see your area representative soon.

Youngstown

ELECTRIC WELD LINE PIPE

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices: - - - Youngstown 1, Ohio.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

How do you choose an executive? Do you want a leader? Or one who goes along with the bosses? The author, a management consultant, takes a whack at 'committee' management and the 'committeemen' hired for executives . . . He believes that to lead in business . . .

You Need Leaderscope

E. A. Butler

WANTED: TOP EXECUTIVE. Unusual opportunity for an imaginative (but not unconventional) planner who thinks quickly (but isn't impatient), acts aggressively (but ruffles no fur), and can get things done (through channels without stepping on toes). Should have a degree in business administration (preferably from an Eastern University), but the equivalent in experience will be considered (for blood relatives of management). Applicant should have varied and broad background (yet be a specialist) and have a work record demonstrating job stability (i.e.: without being a "job-hopper" he must nevertheless have acquired "a varied and broad background"). The man chosen will be a member of an executive committee ("team") jointly responsible (he'd better "fit in") for company policy.

RECOGNIZE this ad? Its appearance in the newspapers, in one form or other, is as commonplace as the Dow-Jones averages. Many business firms, according to their ads, want executives who are imaginative, aggressive, and who possess qualities of leadership. Yet all too often, the man chosen gets the job because he is sober, gregarious, well-liked, inclined to cooperate with the majority, and knows how to wear a grey flannel suit.

Now it is not difficult to find a rugged individualist who also has a taste for Brooks Brothers haberdashery. But to expect him to slip into the conformist mold like so much jelly is quite another matter.

Many companies have exercised this narrow thinking. One company in the East can serve as an example. This firm was organized 13 years ago by a man with an excellent idea for a product that could be widely used. The original number of employees grew from 13 to 400 people. This company with its same president has been extremely successful, and why argue with success? The argument comes because some tarnish is showing.

Two years ago the president became infatuated with multiple management and decided to lighten his own burden by managing the company in group efforts.

Since the group plan was organized, there have been four general managers, three or four sales managers, and unbelievable office help turnover. And as of June, 1956, the plant was unionized.

You can imagine the type of committee that is now running the organization (the management committee) when you know the members are: The 27-year-old son of the president; a former personnel director; the executive secretary, who is earning $6800; the secretary of the company, who is presently out suffering from a severe heart attack; and from time to time the former sales managers, general managers, and chief engineers.

The executive secretary seems to be the "fly in the ointment." Despite his apparent lack of ability, he is personally the man closest to the president. As a result, the company is losing ground rapidly. Although it probably won't be out of business in the next 5 years, competition is rough and management failures are having an irreparable effect on the lives of potentially competent executives.

What is the trouble? In every instance the men who have left this and other companies in a like situation say it is the management committee with its divided responsibility and authority. It is the same malnutrition that invades rigid government bureaus.

These companies manage their business on a basis that the management team needs no individualist for fear he will not "fit in." When new executives are screened, they are tested psychologically, written or oral, to determine whether or not they are pleasantly acquiescent. Employers spend much too much time looking for stability and conformity when what they need is originality and courage.

When circumstances force a company to search outside the organization to fill an important gap, they want hard-driving ambitious executives with new ideas, leadership, clear-cut and positive thinking, and ability to train junior executives. If they find a man through professional executive recruiters or management consultant groups, they are reluctant to bring him into the organization after extensive personal interviews because his personality and his company test aptitudes do not conform. Conformity is probably responsible for their present need, but they do not want to face this.

Management wants accomplishments, but destroys the opportunity of gaining needed creative personnel by seeking out subconsciously the average

EXCLUSIVE

The Author

E. A. Butler established E. A. Butler and Associates, Inc., Philadelphia, Pennsylvania, in 1947. The purpose was to serve as consultant with industries on

problems of selection and classification of employees. Because of demand for executives, executive recruiting, screening and development have had priority in the organization.

"Mr. Ivy League College" or "Mr. Madison Avenue" executive. The average executive is only the best of the worst and the worst of the best. He is not an original thinker — a forceful administrator. Industry cannot survive this type of leveling selection. Average is just not good enough for the tremendous tasks ahead of U. S. management.

Many companies have recruited qualified executives and immediately subjected them to operating committees which are, in most cases, like an oxen yoke to the outstanding capable individual. The attitude of "two heads are better than one" is often ridiculous when politics plays an important part in most management and usually one of the two heads is playing politics. Men are chosen to serve on these committees sometimes merely because of stock holdings or personal favoritism.

Cooperation is obviously vital in management and every company must have a full degree of it to be successful. Cooperation can be achieved as easily by competent qualified administrators; probably more smoothly than by having several persons — some improperly informed — who add little to the discussion table in return for the space and time they occupy.

The force of one competent individual's ability can do more for a corporation than all the groups, committees, teams, or what have you.

If you are looking for a "yes" man, you'll find plenty even in the tight management personnel supply of today. Some are already broken in for "team" functioning.

If you want an executive whose shoes might one day fit under the top man's desk, for business' sake give him his head now. You can't develop management without letting potential managers practice. ★ ★ ★

BIGGEST EVER!

1956
PERMIAN BASIN
OIL SHOW

OCTOBER 18-21
ODESSA, TEXAS

The Permian Basin Oil Show next month will draw the biggest crowds ever (and the previous record topped 150,000). They'll want to see everything that's good, everything that's new in the oil industry. Will you be represented?

This year there's an additional 56,000 square feet of inside exhibit space, but it's going fast. Make sure *your* display is included. *Write today* for contracts and complete information.

PLAN TO GO-PLAN TO SHOW

It's a whale of a show for all the family, bigger and finer for '56. OVER 500 EXHIBITS, nation-wide representation of the newest, finest products and services of the oil industry. HEADLINE ENTERTAINMENT on the stage, starring some of Hollywood's biggest names. 3 dances nightly. Barbecue by the Odessa Chuck Wagon Gang. COMPLETE BOOMTOWN REPLICA, re-built reminder of the early days. Special "Frontier Follies" and old-timers registration. SPACIOUS SHOW GROUNDS with over a million square feet of exhibit area. Ticket books available now.

Address inquiries to:

Permian Basin
OIL SHOW
219 W. Third · Odessa, Tex.

How to Treat the Old Girl

The secretary who does your letters can do a better job if you give her half a chance . . . It will cut costs, too

JOHN RASCO

A couple of years ago some business experts figured out that every letter written cost the average company $1.25. They also determined that business correspondence cost about $6 billion a year.

Needless to say, this figure has been raised somewhat with increasing costs in the past few years. Obviously, such a large investment is worth consideration.

I think any consideration of this should start with the people who are responsible for writing letters.

Of course, the person who composes the letter is important, but this deals primarily with content and style. So, we come to the person who is responsible for producing the finished product, your secretary.

Few businessmen and no secretaries have to be told that the secretary carries the main burden of work in most offices. They not only meet the people coming into your office before you do, but also produce your letters, which are often the only means of another person getting to know you. In quite a few instances, secretaries must make important decisions in your absence. She is your representative, your helper, your greeter and your memory. In short, she's pretty important.

Here are some "do's and don'ts" gathered from various sources that I think are worth passing along. Most of them come from secretaries, and many of them are almost universal points mentioned by secretaries who, after being promised complete anonymity, stated their opinions. Check them over and you'll have a good idea of how you rate with your secretary.

EDITOR'S NOTE: This is taken from "Ideas at Work" in *Texas Industry*, official magazine of Texas Manufacturers Association, Houston, Texas.

★ DON'T:

. . . Treat your secretary like another business machine. Call her by name and introduce her to office visitors.

. . . Bawl her out in front of other office personnel. Corrections and suggestions should be made in the privacy of your own office.

. . . Slip out of the office without telling her where you can be reached. Trust her judgment on when to relay such information.

. . . Call her in for lengthy dictation five minutes before quitting time.

. . . Be afraid to give her an occasional pat on the back for a job well done, and make that the only kind of pat you give her.

. . . Mumble, cough or growl into the dictating machine. She probably has enough trouble following you already.

. . . Use excessive profanity in the office. It displays a weakness in your vocabulary which she is quick to spot.

★ DO:

. . . Respect her as a person and as your helper. Explain the why and how of office work. That's much better than passing out orders.

. . . Organize your office work so that she knows what is to be done and can allocate her time efficiently. Tell her what is to be done and leave her alone to do it. It makes her nervous for you to look over her shoulder, waiting for her to finish.

. . . Let her take time for coffee which she can sip, not gulp.

. . . Let her have an occasional long lunch hour to shop or visit the dentist. Remember her lunch hour is about the only time she has for such things.

. . . Give her good office equipment and provide a well-lighted and comfortable office.

. . . Give her salary raises by merit and not by the decade.

The higher you rate in this list, the better investment you are making. Your secretary represents a considerable expense to the company in letters, salary and other ways. Right now, I'm checking myself to protect our investment. ★ ★

Cut your Pump Room Costs
with
Duraметallic
"Engineered For The Job"
Packings
Write today for FILE No. OMPE describing the complete line of Duraметallic wear-free packings.
The PERFECT SEAL
DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN
MANUFACTURERS OF METALLIC and SEMI-METALLIC PACKINGS
ROTARY MECHANICAL SEALS and PACKING TOOLS

Esso Education Foundation, supported by Jersey Standard companies, was set up to receive and distribute funds to further educational and scientific activities . . . It received $1,500,000 for 1956 . . . This is another method of contributing to higher learning

Education via Grants

THIS year, 193 colleges and universities in the United States received unrestricted grants from Esso Education Foundation. A total of 226 financial grants were made by the Foundation.

This is another method of supporting the educational institutions of the nation. You've seen in one article how one company bolstered scientific education by giving fellowships to science and mathematics teachers,[1] and in another how individual scholarships from one on up to an indefinite number can be given through the National Merit Scholarship Corporation.[2]

This third plan for endowments for education is perhaps the largest made by petroleum companies. Esso Education Foundation was organized in 1954 by Standard Oil Company (New Jersey) and these affiliates: Esso Standard Oil Company, Esso Shipping Company, Esso Research and Engineering Company, Esso Export Corporation and Interstate Oil Pipe Line Company.

Organization Set-Up

The Foundation is operated by an administrative committee composed of executives of the contributing companies. Claude L. Alexander is secretary of the Foundation and the offices are at 49 West Forty-Ninth Street, New York 20, New York.

Trustees of the Foundation are: Eugene Holman, chairman of the board, and M. J. Rathbone, president of Jersey Standard; Jay E. Crane, Chester F. Smith, and E. E. Soubry, directors of Jersey Standard; Stanley C. Hope, president of Esso Research and Engineering.

In 1955 the participating companies pledged $1,500,000. The 226 grants announced in January called for $1,067,900, the largest proportion, $566,000 was given to the 193 privately supported institutions in the form of unrestricted grants for undergraduate education. The recipients were broadly distributed both geographically and by types of institutions. Included were denominational, non-denominational, men, women, co-educational colleges and universities. Forty states and the District of Columbia were represented.

For Capital Projects

The next largest portion of the grants, $200,000 went to 11 colleges and universities for building and other capital projects. A grant of $50,000 was given to United Negro College Fund to be distributed among the 31 institutions it represents. Another 10 grants of $99,900 were made to institutions for assistance in carrying out research projects in the physical sciences. These grants will be used to promote basic research as well as investigations in applied sciences including engineering.

Other grants by the Foundation were for medical education and for special studies being carried on by nine institutions principally in the field of human relations. Jersey Standard and its affiliates contributed about $1,000,000 in individual grants for educational purposes in 1954. These were made before the Esso Education Foundation was organized.

You may remember that it was a suit involving Jersey Standard that first cleared the air for contributions to educational institutions. Before that there was some doubt that this was a legitimate use of stockholders' money. In 1952 a friendly suit was brought by a stockholder against Jersey. The court decided that corporations could make donations to institutions of higher learning. Until this decision industry funds for education were small. Since then donations have greatly increased.

In setting up the Foundation, the companies stated that they did not necessarily feel that they had found the best way to continue their support of higher education but that this method was regarded as a step toward the solution of this important and difficult problem of giving for educational purposes. The statement goes on to point out that many factors are involved in this type of giving and that many ways of contributing are possible.

The Foundation has assumed the function of where to give, how much to give, and for what particular purpose. It is interesting that the largest 1955-56 grants were to privately supported institutions, that they were unrestricted and for undergraduate education. The money thus contributed could go to endowment funds or be used for current expenses as the institution decides. The administrative committee relies upon the advice and cooperation of educators in helping them to reach decisions.

Jersey Companies Contribute

The Foundation will solicit contributions annually from companies in the Jersey Standard group. Its charter provides that "it shall be operated exclusively for educational or scientific purposes . . . to aid . . . by gifts, loans, donations or contributions of the assets or income of the corporation in the . . . maintenance of institutions or organizations engaged in educational or scientific activities."

This is just one more way of trying to solve the problem of higher education for all who can use it with profit . . . another way of supporting the youth of the nation in its search for present knowledge and in its instinct to widen and improve the knowledge it inherits. ★ ★ ★

[1] "Attack on Shortage of Scientists and Engineers" by Ernestine Adams, *The Petroleum Engineer*, E-32 May, 1956.

[2] "You Too, Can Give Help to Education" *The Petroleum Engineer*, E-17 June, 1956.

LAUGH with BARNEY

Ez Tike never realized how hard it was to drive a bargain until he bought that secondhard car.

* * *

Little Billy had gone out in the yard to bring the kittens in.

Suddenly, his father heard some shrill meowing. "Don't hurt the kittens!" he shouted to his son.

"Don't worry, Dad," Billy said. "I'm carrying them by the stems."

When Arthur's mother saw him about to hit his little playmate on the head with the butt of his toy pistol, she ran to him, and scolded him sharply.

"What else could I do?" her son replied, sharply. "I shot him, but he wouldn't fall."

* * *

A friend of ours says he's been burning both ends of the candle and it makes it twice as hard to keep his wife in the dark.

The collection department of a Dallas firm tried a new method on a slow-paying account.

"Dear Mrs. Jones," the letter began. "What would all your neighbors think if we came to your town and repossessed your car?"

In time the letter came back with a message scrawled at the bottom. "I have taken this matter up with my neighbors," it said, "and they think it would be a lousy trick."

* * *

The baby sardine saw its first submarine and went swimming in terror to its mother. "Don't be frightened, darling," she reassured him, "it's only a can of people."

* * *

Margo, six, was always trying to get Johnny, eight, to play domestic games with her. But he refused or made fun of her.

One day she suggested, "Let's play house."

"Ok," he laughed, "I'll be the walls and get plastered."

* * *

Don't blame grandma
If she's bitter,
She's first choice
For baby sitter.

* * *

A camel is an animal that looks as if it had been put together by a committee.

* * *

A Nebraskan, an Ohioan, and a Texan died, and all were scheduled for cremation on the same day.

The Nebraska man was cremated first, and when his ashes were removed, they were put into a quart jar. The Ohio man was next, and his ashes require a pint container.

The Texas man was last. After 15 hours, the furnace door was opened. Out walked the Texan mopping his face with his handkerchief.

"Boy," he said, "if we get two more days of this hot weather, it'll ruin the cotton for sure!"

* * *

Golfer: "I'm anxious to make this shot. That's my mother-in-law up on the clubhouse porch."

Friend: "Don't be a fool, you can't hit her from here. It's 200 yards."

* * *

Joe was having trouble getting up in the mornings, so his doctor prescribed some pills. Joe took them, slept well and was awake before he heard the alarm. He took his time getting to the office, strolled in and said to the boss: "I didn't have a bit of trouble getting up this morning."

"That's fine," replied the boss, "but where were you yesterday?"

* * *

A prisoner was brought before the judge, charged with beating his wife. The judge, being in a sympathetic mood, said: "Do you admit that you would beat your own wife?"

"Why, sure," replied the prisoner. "Whose wife do you beat?"

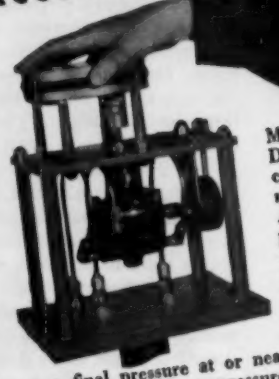
* * *

An Easterner was being driven by a rancher over a blistering and almost barren stretch of West Texas when a large brightly-colored bird scurried across the road in front of them. The visitor asked what it was. "That's a bird of paradise," said the rancher.

"Pretty long way from home, isn't he?" remarked the visitor.

ARCCO

ARCCO-Anubis CONTINUOUS GAS SAMPLER



MEETING THE DEMAND for more accurate gas sampling, this newly perfected ARCCO-Anubis instrument replaces inadequate, inaccurate spot sampling methods. The Model 100-7 will over a period of seven days accumulate at a constant rate a sample of gas to a final pressure at or near 100 psig from a sample source, the minimum pressure of which is not less than 125 psig.

The ARCCO-Anubis design is based on the principle that maintenance of a constant rate of increase in gas pressure within a closed container, from zero to any selected maximum pressure, will result in a continuous rate of flow of gas into the closed container.

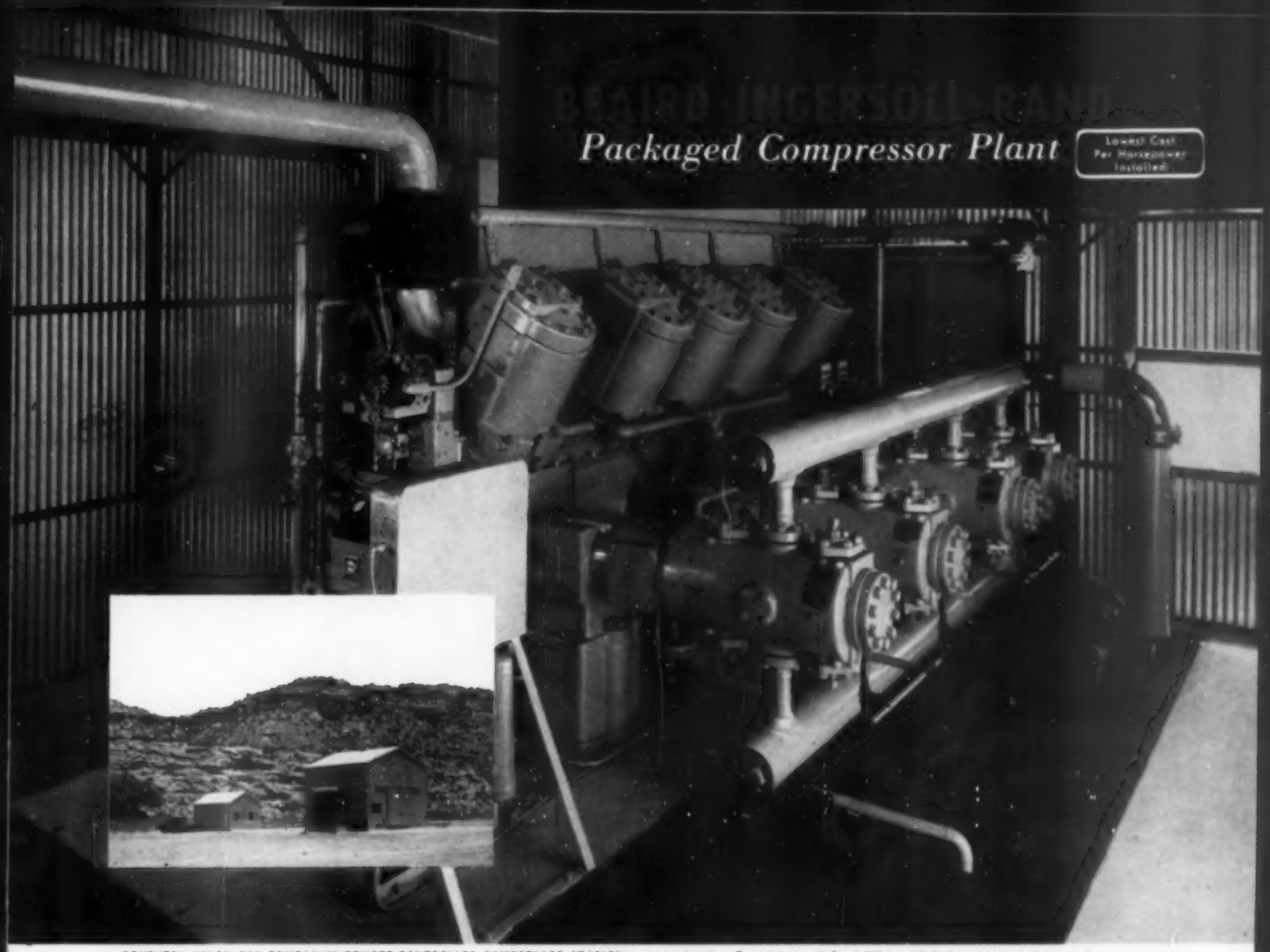
This is accomplished by means of a specially designed regulation system equipped with a precision drive mechanism so as to obtain a constant predetermined rate of increase in the outlet pressure into the sample container.

Send for Bulletin No. 112

AVAILABLE FOR EARLY DELIVERY

AMERICAN RECORDING CHART CO.
3113 E. 11th St. Los Angeles 23, Calif.

SEND FOR BULLETIN 112-RI



Packaged Compressor Plant

Lowest Cost Per Horsepower Installed

SOUTHERN UNION GAS COMPANY'S REMOTE-CONTROLLED COMPRESSOR STATION—equipped with a Beaird-Ingersoll-Rand 550 h.p. 10 SVG compressor. Young radiator with lubricating oil cooler and gas coolers, and all necessary controls for unattended operation. Other sizes 110 to 660 h.p.

Southern Union Gas Company's Dogie Compressor station in El Largo Canyon, New Mexico, is more than 20 miles from the nearest paved highway and many miles farther from the nearest town. To boost gas from this lonely site Southern Union has installed a Beaird-Ingersoll-Rand 550 hp. 10 SVG packaged compressor.

Part of a 500-well gathering system, the Dogie Station compressor uses one stage of compression to pick up gas from 20 wells in nearby Ballard Field and boost it from 250 psig. to 500 psig. for delivery to the main line.

Normally inspected once a day, the station has been designed to overcome potential isolation caused by roads made impassable by deep snow, rain, swollen rivers and washes during severe San Juan winters. This problem of isolation has been solved by equipping the compressor with automatic controls and shut down devices that stand by day and night to protect the station and plant should any unusual operating condition occur. Now on a 40-hour weekly maintenance schedule, the station is capable of long periods of completely unattended operation.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your special operating requirements.

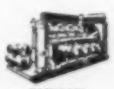
Packaged Compressor for —

REMOTE CONTROLLED

CANYON LOCATION

BEAIRD MACHINING MANUFACTURING STEEL WAREHOUSE

THE J. B. BEAIRD COMPANY, INC.


PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE BULK STORAGE

ANHYDROUS AMMONIA EQUIPMENT

LP-GAS SYSTEMS

SHREVEPORT, LOUISIANA • Sales Offices: *Dallas, Houston, Corpus Christi and Midland, Texas • New Orleans, Louisiana • Tulsa, Oklahoma • Denver, Colorado • Los Angeles, California, and Cie. Ingersoll-Rand, Paris, France*

YOUR
Blue Ribbon
DISTRIBUTOR
NEARBY
Order Blue Ribbon products from your nearby OTM distributor with confidence. You will not only get Blue Ribbon excellence in your flanges, but you will get fully-qualified, expert service.
The supply house near you that handles Blue Ribbon flanges, orifice flanges, long seamless welding necks, ring gaskets and welding fittings has been carefully selected as the best fitted to meet your requirements.
If you do not know the name of your OTM supply house, write, wire or phone:
OTM
CORPORATION
P. O. Box 4625, Phone CA 2-7293
Houston 13, Texas
N OTM DISTRIBUTOR
A Symbol of
EST. 1919
Quality and Service

27-Year Love Affair

Marion L. Campbell has been with Skelly Oil Company, Wichita, Kansas, for 27 years and "loved every minute of it." Since starting, she has been secretary to several men who held the position of Kansas district landman, and feels very fortunate to have worked with and for such exceptionally nice people.

Born, raised and schooled in El Dorado, Kansas, Marion began her work with an abstract company, which she feels provided important back-

Marion Campbell

ground for her present position, as it has been her responsibility to process all titles and papers in connection with lease purchases. Shortly after joining Skelly in 1929, she moved with the land and geological departments from El Dorado to Wichita.

Mrs. Campbell in private life, Marion says she and her husband enjoy their home very much, but are ruled by two kittens. Other "at home" hobbies are gardening and antiques.

Clubwise, Marion is a member of Daughters of Isabella and a charter member of Wichita Oil Secretaries. Since joining Skelly, she has broadened her knowledge with evening classes in oil and gas law, elementary geology, and business administration.

In One-Girl Office

Since graduation from a central Illinois business school, Pearle Graves has been in the oil industry of Chicago. From her first job with Seneca Petroleum, to the present one with Triangle Refineries, Inc., Pearle has preferred a "one-girl office" position, as the work is always more varied.

Her career in the industry has found Pearle with one company in the fuel oil business, others in lubricating oil, one a wholesale marketer, and presently Triangle, also a wholesale marketing concern. She attributes her worth and ability in the industry as coming only from long years of experience with oil companies.

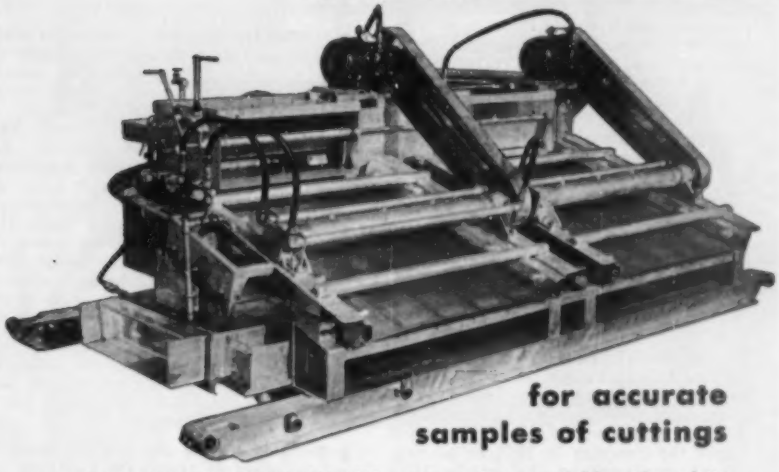
Pearle reports that her outside interests consist of dancing, reading, knitting, playing cards, and, of course, watching television. Her favorite outdoor sport is fishing, and she likes most

Pearle Graves

all spectator sports, especially baseball and football.

Thompson

DOUBLE VIBRATING
SHALE SHAKER...and
SAMPLE MACHINE



for accurate
samples of cuttings

The THOMPSON SHALE SHAKER SAMPLE MACHINE offers the operator and geologist one of the best methods available for obtaining accurate foot-by-foot samples of well cuttings.

This THOMPSON DOUBLE VIBRATING SHALE SHAKER and SAMPLE MACHINE is specially engineered for off-shore barges or islands, deep wells, or wells using big volume and high pressure mud pumps. It is available either plain or galvanized, which makes it rust and deterioration-proof on off-shore or coastal duty

THOMPSON Shakers are famous for their highly efficient service at any depth or flow and for their economical first cost.

Make sure THOMPSON'S on the job for accurate samples and clean mud.

SOLD ONLY
THROUGH
SUPPLY STORES

Thompson
TOOL CO.
IOWA PARK TEXAS

PERSONALS

Robert Gillespie

Robert Gillespie, Commander of the British Empire, was appointed a managing director of The British Petroleum Company Limited, succeeding **E. H. O. Elkington,** retired.

Gillespie joined the organization in 1922, becoming managing director of The British Tanker Company in 1950.

Wallace E. Avery was elected secretary of The Texas Company, succeeding **Walter G. Elicker,** who retired. Avery joined Texaco in 1945 and has been assistant secretary since 1954.

John L. Kent, chief of the editorial bureau of Consolidated Electrodynamics Corporation, is the first president of the newly organized Technical Writing Improvement Society (TWIS). Other officers are: vice president, **Herbert Michaelson,** associate editor of IBM Journal of Research and Development; executive committee members, **Ernestine Adams,** management editor of The Petroleum Engineer, and **Jay R. Gould,** director of Technical Writing Institute at Rensselaer Polytechnic, Troy, New York; executive secretary, **Faith Kildare,** director of instruction of Western Technical Writing Institute, Pasadena, California; treasurer, **George A. Whittington,** who heads his own public relations and advertising firm in Los Angeles.

Joseph Taylor Fly, general counsel and a director of Creole Petroleum Corporation, has retired. He was associated with Latin-American petroleum and legal affairs since 1920, and since 1942 has been with Creole.

J. H. Russell, vice president in charge of pipe line operations and **W. G. Robinett,** assistant comptroller, have resigned from Gulf Oil Corporation. Russell has 35 years of service with Gulf, having first joined the company in 1921 as an electrical engineer in the production department.

H. P. Arbuckle and **P. Superty Jr.** were elected assistant comptrollers of the Gulf Oil Corporation. Both men are veteran employees with long experience in the accounting and auditing phases of the company's operations.

John K. Diederichs was named manager of the engineering economics research department at Armour Research Foundation of Illinois Institute of Technology, Chicago. A former management consultant, he joined the Foundation earlier this year as assistant manager of the engineering economics research department.

Kenneth H. Mounger was named administrative assistant to the secretary-treasurer of Nortex Oil & Gas Corporation. Formerly chief accountant, he joined Nortex in 1955.

Joe D. Nelson is the new controller of Nortex. He was associated with Peppers Refining Company from 1940 to 1950.

Albert D. McCall, petroleum engineer formerly with Shamrock Oil and Gas Corporation, and **W. Leo Morris,** formerly a production supervisor for Magnolia Petroleum Company, have joined the oil loan department at First National Bank and Trust Company, Tulsa, Oklahoma.

John W. Gendron of Tidewater Oil Company was elected president of Iricon Agency, Ltd., succeeding **R. S. Stewart,** vice president of th Standard Oil Company (Ohio).

Stewart now assumes a vice presidency of the agency after serving as its first president under an Iricon policy of rotating executive posts among officials of member companies.

Other newly elected officers include **L. C. Bergquist** of Iricon's London office, vice president; **David E. Day,** Richfield Oil Corporation, vice president; **J. J. Shrewsbury,** Hancock Oil Company, treasurer; **S. K. McCauley,** Atlantic Refining Company, assistant treasurer; **Raymond W. Ickes,** American Independent Oil Company, assistant secretary.

Benjamin Tyran of American Independent and **John K. Schemmer** of San Jacinto Petroleum Corporation were elected to the Iricon board of directors.

Dayton H. Clewell has accepted a position as manager of Socony Mobil Laboratories, with headquarters in New York.

D. H. Clewell

Dr. Clewell has been manager of Magnolia Petroleum Company's field research laboratories in Dallas, Texas. He will be succeeded by **C. I. Alexander,** who has been supervisor of the exploration research division at the laboratories.

Ernest A. Carrere of New Orleans, Louisiana, was elected a member of the board of directors of The Louisiana Land and Exploration Company.

Reese H. Taylor was elected chairman of the board of Union Oil Company of California, and will remain as chief executive officer of the company. **W. L. Stewart Jr.,** formerly senior vice president, is the new vice chairman of the board, and **A. C. Rubel,** formerly vice president in charge of exploration and production, was elected president. **F. L. Hartley,** director of research, was elected a vice president.

A. C. Rubel

R. H. Taylor

Frank R. Denton, vice chairman of the board, Mellon National Bank and Trust Company, Pittsburgh, was elected to the board of directors of Union Oil.

Harry A. Jackson is the new president of American Petrofina, Inc., an affiliate of Compagnie Financiere Belge des Petroles. He was formerly vice president and general manager of eastern operations of Tidewater Oil Company. Jackson has been in the petroleum industry for 35 years, most of the time with Tidewater. He has also served as president of Seaside Oil Company and as an official of several Tidewater affiliates.

George Getty III, formerly of Tulsa, Oklahoma, was named to succeed Jackson.

DEATHS

Harry Clow Boardman . . . 69, director of research, Chicago Bridge & Iron Company, died August 6 in Chicago, Illinois. Previously an instructor at the University of Illinois, he had been with the Chicago company from 1910 to 1916 and since 1926.

Ralph H. Espach . . . 56, chief, branch of petroleum, Region III, U. S. Bureau of Mines, died August 6. Well known for his work in the Rocky Mountain area relating to the production of oil, his most notable accomplishments were his publications. His more than 30 years association with the Bureau of Mines was climaxed in 1954, when he was presented the highest award of the Department of the Interior, the Distinguished Service Award.

Jack H. Lapham . . . 71, a director of The Texas Company, was killed in the crash of a private plane August 2 near Bandera, Texas.

James Anderson . . . 79, retired vice president and treasurer of Humble Oil & Refining Company, died Sunday, July 29, after a long illness.

William H. Burke . . . Tulsa area production manager for Shell Oil Company, died Saturday, July 28, in the St. John's Hospital following a long illness. He had been with Shell since 1932.

E. J. Kirberg . . . coordinator, manufacturing department, Gulf Oil Corporation, died July 19, at Emergency Hospital, Washington, D. C. He first joined Gulf at its Port Arthur, Texas, refinery in 1922, and reached his recent position last fall.

George T. Kelly . . . 49, controller and treasurer of Southern Counties Gas Company of California until he went on disability July 4, 1954, died June 3. Kelly joined Southern Counties in 1948, following a career with Southern California Gas Company since 1929.

Ancil H. Bishop . . . 65, vice president of U. S. Industries, Inc., died recently at Roosevelt Hospital in White Plains, New York, after a long illness. He had spent over 40 years in the Philippines with Koppel (Philippines) Inc., a subsidiary of U. S. Industries, Inc. He became its president in 1951, and after returning to the United States, was elected vice president of U. S. Industries, in 1955. During World War II, Bishop was interned for 37 months in the Philippines as a prisoner of war of the Japanese.

Ray S. Kail . . . formerly sales manager for Rolo Manufacturing Company, and for the past year Rolo representative for the North Texas area, died recently of a heart attack at his home in Stamford, Texas.

A New FIELD VALVE by FISHER®

Series 125P

HIGH PRESSURE DIAPHRAGM CONTROL VALVE

- RUGGED CAST STEEL BODY GOOD FOR 2000 psi PRESSURE
- ONE INNER VALVE FITS ALL ORIFICES
- TOPWORKS INTERCHANGEABLE ON ALL BODIES
- DIAPHRAGM CASINGS SUITABLE FOR 50 psi OPERATING PRESSURE
- TOPWORK ACTION REVERSIBLE WITH NO ADDITIONAL PARTS

WRITE FOR BULLETIN O-125P

Hi-Low Safety Valve

Separator Oil Valve

Time Cycle Intermitter

SPECIFICATIONS

Body—Cast Steel—2000 psi WOG

Sizes—1" and 2" screwed angle or globe

Orifice Size—1" Body—¼", ⅜", ½", ¾"
2" Body—¼", ⅜", ½", ¾", 1"

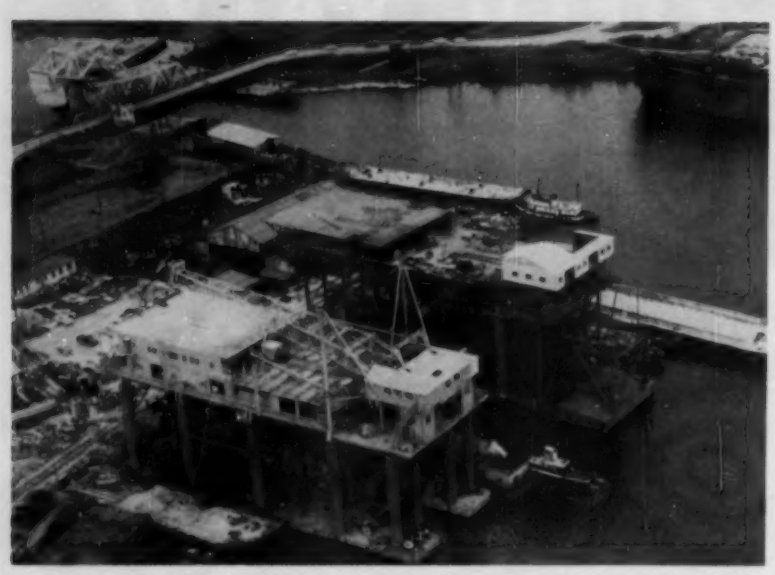
Valve Cage—440 hardened St. Steel. (Tungsten carbide insert also available.)

Inner Valve—440 hardened St Steel (Tungsten carbide tip also available.)

FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA · WOODSTOCK, ONTARIO
LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER Since 1880

OIL and GAS TRADE NEWS



Two deep water drilling giants designed and constructed by American Marine shown in this view of its yard No. 2, New Orleans, Louisiana.

Alexander Shipyard Reorganizes as American Marine

Alexander Shipyard, Inc., is facing the future under a new name, American Marine Corporation, with a reorganization and expansion program.

President of the reorganized company is Leslie B. Durant, formerly vice president and general manager of Alexander Shipyard. H. E. Breit, Jr., formerly Alexander chief engineer, is vice president, and assistant vice president will be W. H. Michel, formerly in charge of research and development with Gibbs and Cox, Inc., naval architects of New York City.

Included in the expansion program are a new gas-freeing plant, a 1500-ton floating drydock, a 50-ton floating derrick, and a new 16-ft, 600-ton hydraulic press for the forming of steel plates. Three more giant-size, offshore drilling rigs are in the process of design or construction.

Rockwell Plans New Plant

Rockwell Manufacturing Company plans to occupy a new 180,000-sq-ft valve manufacturing plant at Kearney, Nebraska.

Company officials estimate the new plant, expected to be completed by midsummer of 1957, will cost approximately $2,000,000.

Located on a 52-acre plot, the plant will be used for machining, assembly, and testing of Rockwell-Nordstrom Hyperseal valves. Most of the personnel employed will have to be specially trained by the company.

Allis-Chalmers Dealers Have All Its Oil Field Units

Allis-Chalmers Manufacturing Company, tractor group, announces that all models of its oilfield engines and power units manufactured at its West Allis, Wisconsin, Works and Harvey, Illinois, Works are now available to the petroleum industry through all of its engine dealers.

These include its Models B-125 and W-226, which have been available heretofore through Fred E. Cooper, Inc.

The Cooper firm continues to represent Allis-Chalmers in the Tulsa, Oklahoma, area and will now handle the sales and service of the complete line of natural gas, butane, propane, diesel and gasoline engines in sizes from 9 to 516 hp.

Garrett Begins New Plant

Garrett Oil Tools, Inc., a division of U. S. Industries, Inc., has begun construction of new plant and office facilities on a 39-acre tract at Longview, Texas.

Facilities will include three buildings with a total of 75,000 sq ft of floor space. The manufacturing plant will cover some 57,000 sq ft, with the balance devoted to accounting and executive offices and an engineering-research building. Total cost will be approximately $1,000,000, with completion expected about Jan. 1, 1957.

The separate engineering, research and development building will contain a complete machine shop and a 1000 ft well with 95 ft derrick.

Continental Parts Depot

The industry's first parts depot supported by a machinery service organization, located at Morgan City, Louisiana, was recently announced by Continental Supply Company.

This parts depot, operating independently of Continental's store at the same location, will carry a full inventory of parts for Emsco equipment and Gardner-Denver mud pumps.

Billy Mills, formerly in charge of service for Continental Supply at Corpus Christi, Texas, was named district service manager.

Second LeTourneau Offshore Unit

R. G. LeTourneau, Inc., has signed to build a $3,225,000 offshore drilling platform for Zapata Off-Shore Company of Houston, Texas, with delivery scheduled for early 1957.

This portable platform is the second to be built by LeTourneau for Zapata. The new platform will be somewhat larger than the first and will incorporate a number of improvements.

LeTourneau will build the platform near its Vicksburg, Mississippi, plant. Completion will be about February 1.

Otis Engineering Buys Cummings

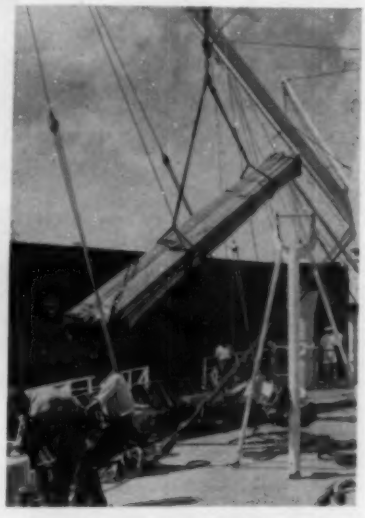
Otis Engineering Corporation has announced the purchase of Cummings, Inc., Houston, manufacturers and distributors of Cummings gas lift valves.

All Cummings employees, including Les L. Cummings, the Houston firm's president, will be retained in the Otis organization. Cummings has been named manager of the gas lift division for Otis in Houston.

Tubing Cement Service Extended

Lane-Wells Thru-Tubing Cementing Service, which has been available in the Houston, Texas, area since early in the year has been extended to include the southern Louisiana territory.

Lane-Wells tools available on the truck for running wireline and cementing services include 500 ft of extensible 1-in. aluminum pipe with two 10 ft telescoping joints for sandwashing operation.



First shipment of aluminum pipe leaves for Pakistan. More than 12 miles of the new type pipe manufactured by Race & Race, Inc., is included in the shipment, which will be used by the Penrod Drilling Company in its drilling operations in the oil fields of Karachi, Pakistan. The aluminum pipe is equipped with special quick locking and unlocking couplings for easy laying and handling.

ASME President Nominated

William F. Ryan, vice president, director, and senior consulting engineer of Stone & Webster Engineering Corporation, has been nominated to serve as the 1956-57 president of the American Society of Mechanical Engineers.

He will be installed at ASME's annual meeting in New York in November, after a letter ballot of the organization's 41,000 members.

Also nominated were the following: as technical director, Eugene W. Jacobson, chief design engineer, Gulf Research & Development Company, and as administrative director, V. Weaver Smith, vice president in charge of contracts, the Lummus Company.

National Supply Opens Stores

The National Supply Company has opened two new oil field supply stores, one at Cortez, Colorado, and one at Aspermont, Texas.

E. L. Ayala has been named manager of the Cortez store, while T. W. Overbey Jr. has been made manager of the Aspermont store.

South American Agents Named

Franks Division, Cabot Shops, Inc., announces the appointment of exclusive distributors in South America for its line of well servicing units and rotary drilling rigs.

East-West Oiltools, C. A., will cover the Venezuela and Colombia regions, while Servicios Petroleros, S. A., will have the Peru-Ecuador area.

Sales and service personnel of both East-West Oiltools and Servicios Petroleros have recently completed a comprehensive training course at Franks' Tulsa, Oklahoma, headquarters plant.

Tube Turns Expansion Program

Tube Turns, a division of National Cylinder Gas Company, has bought 13 acres of industrial property for expansion purposes. Price was $2,000,000.

The property is adjacent to Tube Turns' main plant.

Earlier, 2.6 contiguous acres were acquired, and the new production area now totals 15.6 acres.

The two real estate transactions will be followed by a substantial investment in additional equipment.

New Trucks for Service Fleet

BJ Service, Inc., has increased its fleet of trucks with the introduction of a wire line shooting truck and a companion radioactive logging truck.

This new shooting truck is equipped to carry 20,000 ft of cable for handling the deepest wells drilled today. This unit contains the latest instrumentation and covers all wire line services. The companion unit, the simultaneous radiation logging truck, is the most recent addition to BJ Service's R/A logging service.

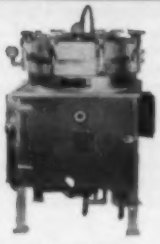
Rolo Ends Preliminary Expansion

Rolo Manufacturing Company has announced completion of the first stages of a planned quarter-million dollar expansion program.

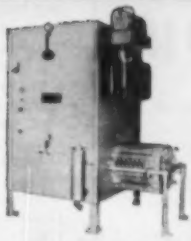
Plant buildings and manufacturing facilities have been greatly increased, and an increase in company personnel and stocks of finished products is anticipated.

Anticipating the trend toward automation in oil production, Rolo is expanding its engineering and research operations to meet the requirements for any type of automatic metering installation.

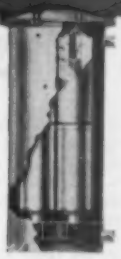
HILCO LUBRICATING and INDUSTRIAL
Oil Maintenance Equipment
Saves Your Oil, Money and Machinery



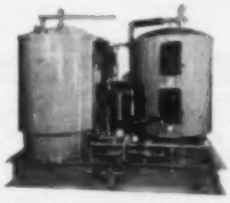
OIL RECLAIMER
For continuous oil purification in range of 2-100 gph. Removes all solids, acids and volatile contaminants.



PURIFIER-RE-REFINER
For oil purification in batches of from 6 to 100 gallons. Removes all solids, acids and volatile contaminants.



FILTER
Furnished in capacities from 0.1 to 750 gpm. Various cartridges available for mineral and inhibited detergent oils.



HIGH CAPACITY RECLAIMER
Combines filtration for removal of solids and sludge with vacuum vaporization for removal of solids, acids, water, solvents, fuel dilution. Furnished in standard or custom built models to 600 gph.

HILCO purification means *complete* oil purification . . .

Whenever oil is used it becomes contaminated and must be discarded or conditioned for further use. There is a HILCO to do this job for you. You can recover large quantities of oil at low cost. HILCO units are available for continuous or batch operation.

A COMPLETE LINE OF EQUIPMENT FOR RECLAIMING, FILTERING, PURIFYING AND REFINING OIL FROM . . .

- Diesel Engines
- Trucks
- Tractors
- Gasoline Engines
- Gas Engines
- Automobiles
- Buses
- Heat Treating Systems
- Locomotives
- Steam Turbines
- Steam Engines
- Air Compressors
- Vacuum Pumps
- Transformers
- Circuit Breakers
- Wire Drawing Machines
- Hydraulic Equipment
- Metal Rolling Mills
- Paper Making Machinery
- Oil Bath Oil Air Filters

THERE'S A HILCO TO DO THIS JOB FOR YOU
• CONSULTING ENGINEERS •
WRITE TODAY! FOR THE NEW HILCO CATALOG FOR COMPLETE INFORMATION AT NO OBLIGATION . . .

THE HILLIARD Corporation
W. FOURTH STREET • ELMIRA, NEW YORK
IN CANADA: Upton-Bradeen-James Ltd., 890 Yonge St., Toronto; 3464 Park Ave., Montreal

GALVESTON

A sparkling isle in the Gulf of Mexico, sprinkled with palms, oleanders, and other tropical plants. 32 miles of beach and sparkling surf to enjoy. All sports and entertainment facilities. Fishing is tops—night life bright—perfect for your vacation. Write today for color folder and full information.

Your hosts on the beach are

hotel BUCCANEER and hotel GALVEZ

- SWIMMING POOL
- COMPLETELY AIR CONDITIONED
- TELEVISION — RADIO
- SUPERB SEAFOOD

AFFILIATED NATIONAL HOTELS

ALABAMA
HOTEL ADMIRAL SEMMES ..... Mobile
HOTEL THOMAS JEFFERSON ..... Birmingham
DISTRICT OF COLUMBIA
HOTEL WASHINGTON ..... Washington
INDIANA
HOTEL CLAYPOOL ..... Indianapolis
LOUISIANA
JUNG HOTEL ..... New Orleans
HOTEL DESOTO ..... New Orleans
NEBRASKA
HOTEL PAXTON ..... Omaha
NEW MEXICO
HOTEL CLOVIS ..... Clovis
SOUTH CAROLINA
HOTEL WADE HAMPTON ..... Columbia
TEXAS
HOTEL STEPHEN F. AUSTIN ..... Austin
HOTEL BROWNWOOD ..... Brownwood
HOTEL BAKER ..... Dallas
HOTEL TRAVIS ..... Dallas
HOTEL CORTEZ ..... El Paso
HOTEL BUCCANEER ..... Galveston
HOTEL GALVEZ ..... Galveston
HOTEL JEAN LAFITTE ..... Galveston
CORONADO COURTS ..... Galveston
HOTEL PLAZA ..... Laredo
HOTEL LUBBOCK ..... Lubbock
HOTEL FALLS ..... Marlin
HOTEL CACTUS ..... San Angelo
HOTEL MENGER ..... San Antonio
AMORES COURTS ..... San Antonio
VIRGINIA
HOTEL MOUNTAIN LAKE ..... Mountain Lake
HOTEL MONTICELLO ..... Norfolk

TELEPHONE
NEW YORK—Murray Hill 66990
CHICAGO—Mohawk 65100
WASHINGTON—Executive 36481
MEXICO CITY—10-4800
GALVESTON—5-8536
CLEVELAND—Prospect 1-7827

AFFILIATED NATIONAL HOTELS

Trade News

Cosasco Sold to Perfect Circle

Perfect Circle Corporation announces the purchase of Corona Oil Specialties & Service Company (Cosasco), manufacturer of special oil well equipment embodying the patented "Scotch Nipple" principle.

Cosasco will become a division of Perfect Circle. Sale price was not disclosed.

Jay P. Gould will continue as manager of the new Perfect Circle division and Cosasco's headquarters will remain in La Canada, California.

Cost Engineers Form Group

The American Association of Cost Engineers was organized on June 2 at a meeting held on the campus of University of New Hampshire, Durham, N. H.

President of the new group is Norman G. Bach, supervisor of engineering services for Monsanto Chemical Company at Texas City, Texas. Other officers are: vice president, J. W. Hackney, chief construction engineer for Diamond Alkali Company, Cleveland, Ohio; secretary, John T. Husted, chief estimator for American Potash & Chemical, Trona, California; treasurer, Bruce R. Landis, chief estimator for C. W. Nofsinger Company, Kansas City, Missouri.

Dow Corrosion Control Viewed

Corrosion-conscious representatives from 27 major oil and chemical companies recently got a close look at The Dow Chemical Company's corrosion control program.

Some 50 representatives were guests of Dow's Texas division operations at Freeport, Texas.

The history of Dow cathodic protection was outlined for the visitors and a discussion on current developments in cathodic protection was presented.

Petroleum Trust Department

Establishment of an oil division in the trust department of the Republic National Bank of Dallas, Texas, to permit specialized handling of estates and trusts whose assets include petroleum interests, has been announced.

Heading this newly created division will be George E. Wilkin Jr., a graduate petroleum engineer with many years' field experience in petroleum production.

Operation of the trust department's new oil division will be entirely separate and independent of the bank's petroleum department.

Schramm Expands Factory

Ground has been broken by Schramm, Inc., for a one-story building 600 ft by 60 ft, which will increase the factory floor space from 145,000 to 181,000 sq ft.

Use of this building will be for final assembly, painting and shipping.

National Carbon Lab Dedication

The new Parma, Ohio, research laboratories of National Carbon Company, a division of Union Carbide and Carbon Corporation, will be dedicated September 18.

Designed primarily for basic research in chemical and solid-state physics, the multi-million dollar laboratory facilities are already in operation.

Laboratory contains approximately 175,000 sq ft of floor space, and is located on a 126-acre plot.

STITT
NEW
triple
ignitor
SPARK PLUGS
Cut
"DOWN" TIME
"Down" time is costly and unproductive. Stitts run longer—cut down time for plug changes and mag checks. It's not the plug price, but the "change cost" that's important! Stitts cost a little more—save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.
Write for Field Test Reports
Free $1 Gap Gauge
STITT Ignition Company
Columbus 1, Ohio
Get STITTS From:
BELL ENGINE SERVICE
BETHLEHEM SUPPLY CO.
CLARK BROS. CO.
COOPER-BESSEMER CORP.
HOPEMAN EQUIPMENT CO.
INGERSOLL-RAND CO.
JNO. MULLER CO.
REAGAN EQUIPMENT CO.
WAUKESHA ENGINE & EQPT. CO.
WAUKESHA-PACIFIC
WAUKESHA SALES & SERVICE Inc.
WORTHINGTON CORP.
MAGNETO IGNITION SERVICE R. ANGUS (ALBERTA) Ltd. CAN.
. . and Supply Stores Everywhere.

TRADE PERSONALS

B. R. Braznell

M. J. Conley

P. D. Nerren

W. A. Gormley

R. O. Wynn

▸ **Robert O. Wynn** has been elected vice president of manufacturing for W-K-M Manufacturing Company, Inc. Wynn first came to W-K-M as chief engineer in 1951 and most recently was serving as director of manufacturing.

M. J. (Bud) Conley is the newly appointed sales manager of the drilling and production valve department. He has been with W-K-M for 10 years as sales representative in the Gulf Coast area.

Bart R. Braznell has been named sales manager of the KEY products department of W-K-M. Braznell was with the former Key Company for 26 years and was formerly its sales manager.

Paul D. Nerren is the new sales manager of the W-K-M pipe line valve department. Nerren came up through the valve production side of the company, being promoted to sales and service in 1947.

William A. Gormley was made sales manager of the ACF lubricated plug valve department of W-K-M. Gormley was with the former ACF valve division, Detroit, Michigan, serving as sales manager for 19 years.

W-K-M is a subsidiary of ACF Industries, Inc.

▸ **Maxwell D. Millard,** who started his steel sales career as a technical apprentice with American Steel & Wire Division in 1934, has been appointed general manager of sales for this division of United States Steel Corporation.

▸ **Clyde Crozier** has been appointed European territory manager, tractor group, Allis-Chalmers Manufacturing Company. He succeeds **Myron W. Rhoten,** now managing director of Allis-Chalmers Great Britain, Ltd. **John Feustel** has been named Africa and Middle East territory manager.

▸ Otis Pressure Control, Inc., and its manufacturing affiliate, Otis Engineering Corporation, have announced a realignment of executive personnel.

Lowell M. Wilhoit, vice president of sales and service for Otis Pressure Control, has been appointed vice president in charge of engineering for Otis Engineering. **James E. McGinley,** former personnel director for Otis Engineering, was transferred to Otis Pressure Control as director of sales and service.

Kenneth W. Robbins, formerly service manager, was named to a new position of director of export department sales and service. **Warner M. Kelly,** former division manager and chief caliper engineer for Otis in Houston, Texas, was transferred to Dallas, Texas, to take Robbins' former position. **Carl M. Schwab,** former chief engineer for Otis Engineering, was transferred to Houston as division manager for Otis Pressure Control.

Harry M. Schramm, former vice president in charge of engineering, was appointed vice president in charge of research and development for Otis Engineering. **Stanley Noska,** former general foreman of production, was appointed plant superintendent.

▸ **Russell W. Chaffin** has been appointed general sales manager of the industrial rubber division, Thermoid Company. Chaffin was previously western division sales manager in California.

▸ **O. L. Lorehn** has been named coordinator of supply and manufacturing and **I. M. Baker** as coordinator of sales for the International Division of Cameron Iron Works in Houston, Texas.

R. E. Hager has been named manager of Cameron Iron Works of Canada to succeed **Gene Teer,** who is being transferred to Houston to manage the Houston office of the international division.

▸ **J. P. Magoffin** has been made product sales manager for BJ Red Top Centralizers and Scratchers for Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corporation.

▸ **Jack Gissler,** resident manager of Lufkin Machine Company, Ltd., at Edmonton, Alberta, Canada, has been named vice president of the company. **H. L. Dyer** of Lufkin, Texas, was made secretary.

Offices and warehouse of Lufkin Foundry and Machine Company, International have been opened in Maracaibo, Venezuela.

Officers of Lufkin International are **L. A. Little,** president; **A. V. Simonson,** vice president; Dyer, secretary-treasurer.

Ben Sargent Jr. is South American division manager, and **Howard Hogue,** who recently was transferred from the home office in Lufkin to Maracaibo, will be Venezuelan sales and service manager.

▸ **B. C. Prowell** has been appointed an area supervisor in the Rocky Mountain division of Continental Supply Company. **Ray R. Schramm** succeeds him as store manager for Continental's Sterling, Colorado, store.

G. T. Bowman

J. W. Northcutt

J. H. Walters

W. D. Willes

▸ **Gilbert T. Bowman,** general products manager, and **J. W. Northcutt,** southern regional sales manager, for the meter and valve division, have been named assistant vice presidents of Rockwell Manufacturing Company. **Jack H. Walters,** product manager-petroleum and industrial liquid meters, will move to Rockwell's southern regional headquarters in Atlanta, Georgia, to succeed Northcutt.

Weldon D. Willes, product manager — Nordstrom valves, is now assistant to the president of Rockwell's recently acquired Locomotive Finished Material (LFM) division.

▸ **K. Russell Knoblauch** has been appointed sales manager for the oil and chemical industries for the eastern region of Minneapolis-Honeywell Regulator Company's industrial division.

▸ **Milton L. "Lump" Talbert** has been named assistant chief engineer for the Dallas, Texas, rock bit plant operations of Security Engineering Division, one of the Dresser Industries. Talbert was connected with another major bit manufacturer from 1936 until 1952.

▸ Houston Oil Field Material Company, Inc., announces the opening of a new sales and service office in Lafayette, Louisiana. The following personnel will be located there: **C. H. Pollard,** assistant general manager, directional drilling in Louisiana and Mississippi; **Leon LaBauve,** service representative; **J. O. (Jack) Duncan,** oil field supplies sales; **Gordon Harrigan,** directional drilling sales engineer.

▸ **C. T. Patten** has been appointed district manager of the new Welex Jet Services office in Houma, Louisiana. **Gordon McLaughlin** has been named district manager of the district office at Falfurrias, Texas.

▸ **J. T. Mitchell,** former branch manager, Odessa, Texas, for Baker Oil Tools, Inc., has been appointed assistant district manager, West Texas district, with headquarters in Odessa.

J. V. Bergman, branch manager, Farmington, New Mexico, will transfer shortly to Midland, Texas, as district sales engineer, West Texas district.

Trade Personals

L. L. Durkin is being transferred from New Orleans, Louisiana, to Houston, Texas, and assigned to city sales by Well Equipment Manufacturing Corporation. Durkin will be succeeded in New Orleans by **Dale DeLong.**

I. D. Abshire is being transferred to the new Dallas-Fort Worth-North Texas area. Abshire is being succeeded in Corpus Christi, Texas, by **Mat (Mack) Bowen** who will serve the South Texas area.

A. H. (Watty) Watts is being transferred from Graham to Abilene, Texas.

W. C. Gray has been named special sales representative for the Mid-Continent region by Security Engineering Division, one of the Dresser Industries. At the same time, **T. H. Patterson** was promoted to Oklahoma division sales manager to fill the position vacated by Gray.

Walter P. Barrett has been appointed manager of the pipe fabrication department of Dravo Corporation's machinery division.

V. W. Grotlisch has been transferred to Midland, Texas, as a representative of the general office sales department of Dowell, Inc.

Five new Schlumberger Well Surveying Corporation locations have been established, three in Texas and one each in Louisiana and Nebraska.

Locations and their managers are: Andrews, Texas — **R. G. Tefft;** Carrizo Springs, Texas — **P. R. Edling;** Perryton, Texas — **C. E. Tedrow;** Franklin, Louisiana — **George Broussard;** Kimball, Nebraska — **W. F. Stephen.**

Guy W. Tucker has been transferred to district manager of the Rocky Mountain area, Denver Colorado, by American Iron & Machine Works Company, Inc. **W. L. Martin** has been moved to the eastern division, where he will have the title of district manager.

Three changes in personnel in the drilling mud department of Magnet Cove Barium Corporation have been announced.

James Carlton, formerly district manager in Mississippi, has been reassigned to Shreveport, Louisiana, as division sales representative. **R. B. Foil,** formerly sales and service engineer in Shreveport, has been named district manager in Mississippi.

James DeBusk, formerly sales and service engineer in the Mid-Continent division has been appointed division sales representative in California. He replaces **James Homan,** who has resigned to enter private business.

William F. Winkler has been elected a vice president in charge of sales of Midwestern Engine and Equipment Company, Inc. Winkler has been sales manager for Midwestern for the past three years. Appointment of **Robert Karlovich** to the position of secretary-treasurer was also announced. Karlovich had previously served as assistant secretary and treasurer.

W. Roberts Wood has been elected president of the Girdler Company, a division of the National Cylinder Gas Company. Wood succeeds **George O. Boomer,** who retired as Girdler's operating head but will continue as chairman of the executive committee of the parent company.

Hallberg "Bud" Hanson has been appointed by the Chicago Division of The Kendall Company as plant manager of its new Polyken industrial tape plant now under construction at Franklin, Kentucky. Hanson, who has been with the company since 1946, was most recently staff assistant to the production manager at the Chicago plant.

Carl W. Petersen has been elected executive vice president of Dodge Manufacturing Corporation. He was previously vice president and works manager.

George R. Buchanan Jr. has been appointed associate manager of petroleum chemicals sales for Monsanto Chemical Company's organic chemicals division. Buchanan was formerly manager of resin materials and functional fluids in the division's development department.

Charles M. Scholz has been elected vice president of Thermoid Company. Scholz had been assistant to the president in a sales coordinating capacity.

Francis D. Holden has been elected vice president in charge of sales for Macwhyte Company. Formerly sales manager, Holden has had more than 20 years' experience in the general sales and export division.

Clinton F. Hegg, vice president of the L.O.F. Glass Fibers Company, has been named general sales manager of the company. He was formerly in charge of the automotive sales division. In his new post, Hegg replaces **J. M. Johns,** whose resignation was announced earlier.

Carl J. Siebert has been appointed sales manager of W-S Fittings Division, H. K. Porter Company, Inc. Siebert was district manager of the Chicago, Illinois, office prior to his present appointment.

L. J. Lieberthal has been appointed general manager of the Conduit Fittings Corporation, a division of U. S. Industries, Inc. Lieberthal succeeds **M. J. Weiss,** who recently resigned. Weiss will continue in a consulting capacity to the division until December 31. Lieberthal has been with USI since 1946.

J. R. Stein, assistant general manager of The Dow Chemical Company's Texas division, has been appointed project manager in active charge of constructing and developing the company's new Louisiana division. Dow personnel will take over key posts immediately with offices in the Baton Rouge area.

Verner G. Lofstrand has been named sales representative for the western provinces of Canada with Enardo Manufacturing Company. Lofstrand has spent the past five years in the Canadian oil field supply service.

R. A. Prater, formerly district manager at Wichita Falls, Texas, is now assistant general manager of sales for Republic Supply Company. **F. H. Anthis,** formerly city sales representative at Oklahoma City, Oklahoma, has been made district manager at Wichita Falls.

A. R. Tullos, Gulf Coast division sales manager, Kobe, Inc., is being transferred to Midland, Texas, where he will be West Texas division sales manager. **J. T. Lewis,** who has headed the West Texas division, will go to Houston to succeed Tullos.

CORROSION RESISTANT LINE
GLARE FREE MARKINGS
TOUGH LEATHER CASE

EASY TO READ MARKINGS

LUFKIN

ANCHOR
Chrome Clad
STEEL
TAPE

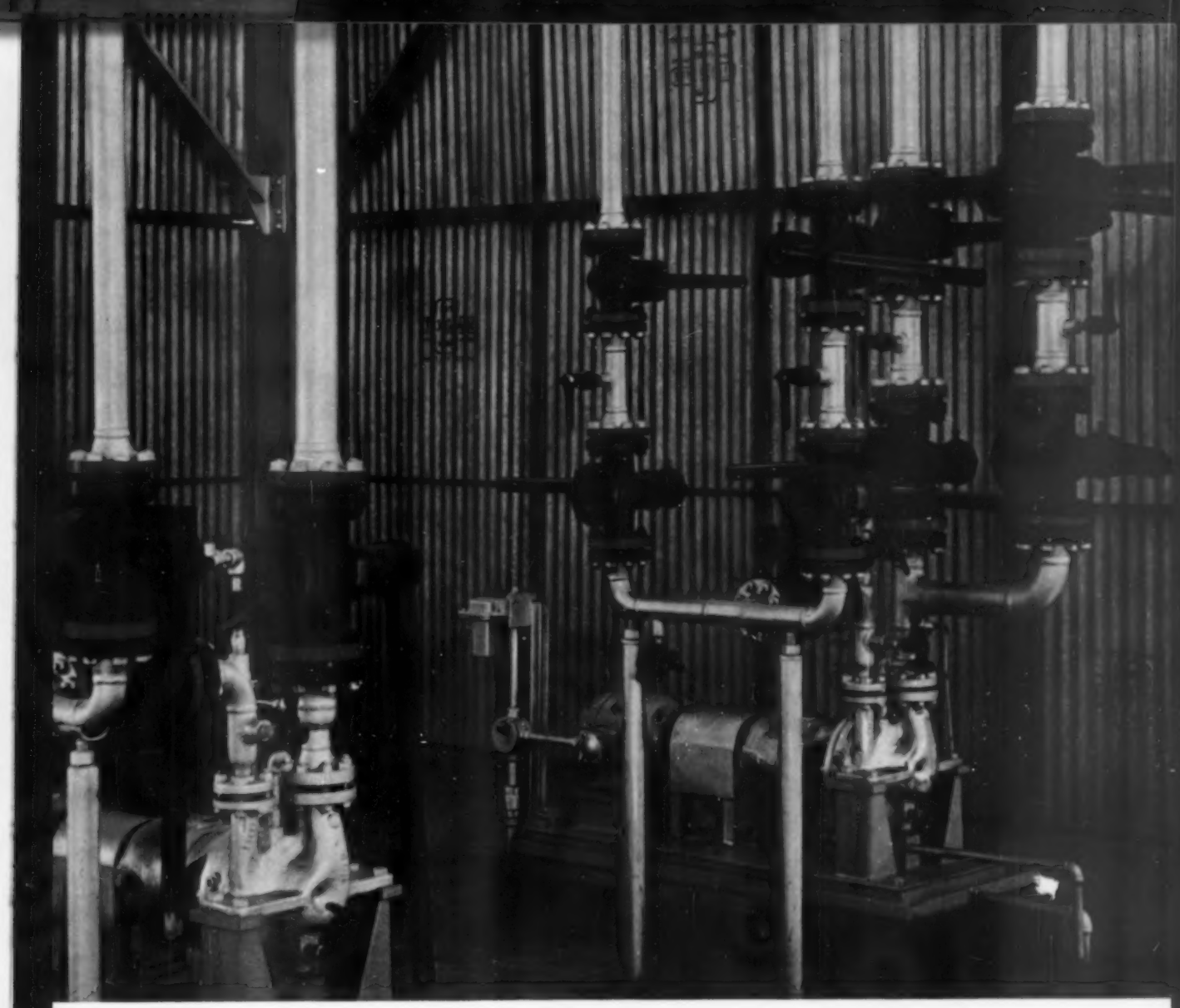
Bold black markings contrast with exclusive "glare-free" Chrome Clad surface on Lufkin "ANCHOR" Steel Tapes. Multiple coats of electroplate add strength and protection. Wipes clean and is tarnish-proof. Handsome, genuine leather case, hand stitched, with rust-resisting metal liner. Replaceable lines in 25 to 100 foot lengths.

BETTER MEASURE WITH LUFKIN

BUY LUFKIN TAPES • RULES • PRECISION TOOLS FROM YOUR SUPPLY HOUSE

THE LUFKIN RULE COMPANY • Saginaw, Mich.
New York City • Barrie, Ontario

391



The "extras" cost no more

When you use Rockwell-Nordstrom valves you get "extras" you can't buy in ordinary valves. Pressurized lubrication in the Sealdport* system assures leakproof sealing (without uncertain "forced" seating), and eliminates costly wearing friction. Because they are rotary plug valves, quarter-turn operation and unexposed seating are two more money saving extras. The cost? Rockwell-Nordstrom valves cost no more to buy (often less) than ordinary valves and cost much less to use.

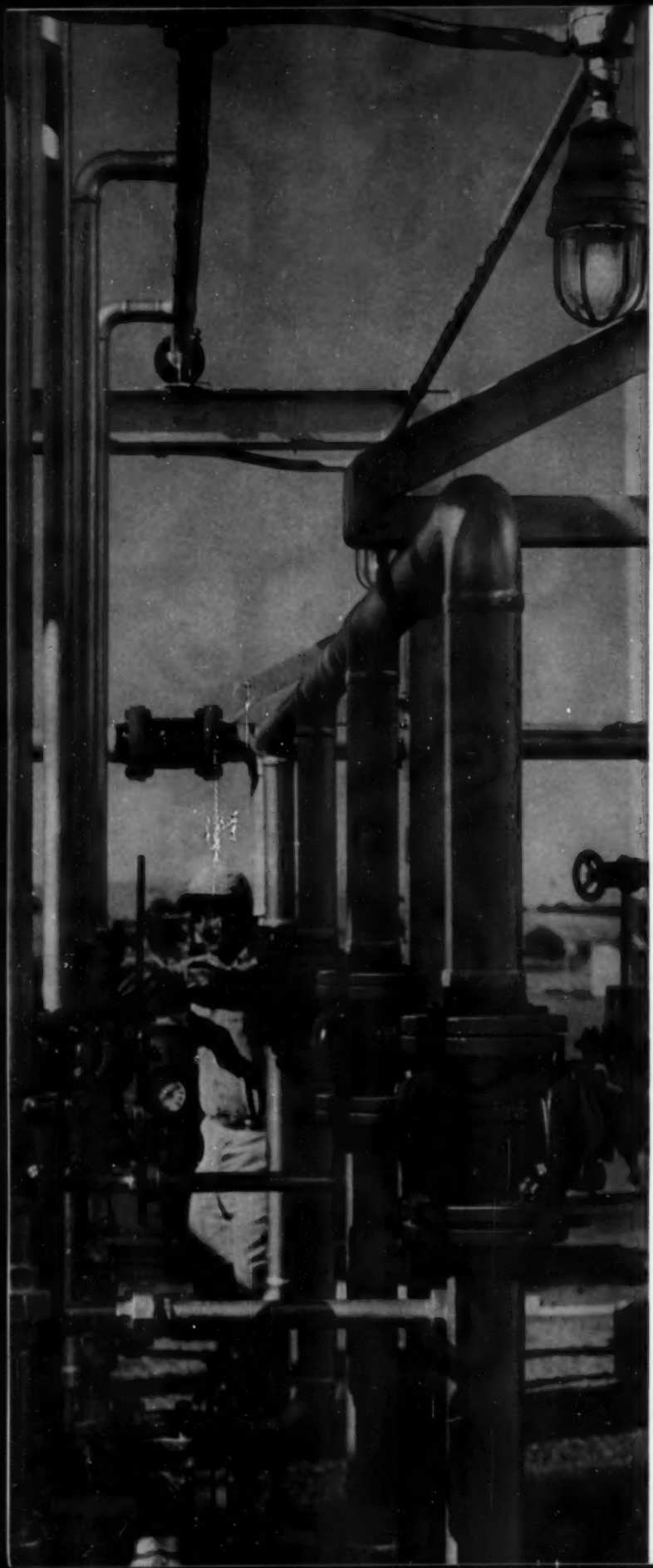
Forty years of lubricated plug valve leadership by the original and world's largest manufacturer is your assurance of economy and trouble-free dependability when you specify Rockwell-Nordstrom valves. Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

*A registered trade mark of Rockwell Manufacturing Company.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

40th Year *of lubricated plug valve leadership*



Complex manifolding made easy

You can use Rockwell-Nordstrom valves in complex manifolds where ordinary valves wouldn't even begin to fit. Because they have no heavy, bulky bonnet cavities or rising parts, Rockwell-Nordstrom valves take little more space than their flange diameters. Additional advantages: positive shut-off prevents product contamination; firmly seated plug and rugged construction prevent shock load failures that are common to ordinary valves on pulsating flow.

Rockwell-Nordstrom valves cost no more to buy than ordinary valves—and they cost far less to *use*. Available in a complete range of sizes and pressure ratings in semi-steel, steel, stainless and corrosion resisting metals. For details, write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

Available at leading suppliers . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-off

40th Year
of lubricated plug valve leadership

Thomas H. Evans, who has been serving as controller for Lane-Wells Company, has been elected secretary of the company and made administrative assistant to the president.

T. H. Evans

W. H. Bruyere

William Henry Bruyere has joined Houston Contracting Company, where he will function as assistant to management. Bruyere was with American Oil Pipeline Company, Houston, Texas, as chief engineer.

L. O. (Lee) Weaver has been named Tulsa, Oklahoma, city sales manager for Maloney-Crawford Tank & Manufacturing Company.

A. E. Higginbotham has been promoted to the newly created position of district sales manager for the Southeast USA for Mission Manufacturing Company, and will be located in New Orleans, Louisiana. Higginbotham has been with Mission as a field salesman since 1946 in the territory including southern Louisiana and Mississippi.

R. M. (Randy) Smith has joined the engineering staff of Corrosion Services, Inc., where he will assist in the designing of cathodic protection systems for pipe lines, oil well casing, and similar uses.

Smith was formerly senior corrosion engineer with Great Lakes Pipe Line Company, Des Moines, Iowa.

Harold J. Myers has been named supervisor of product sales for Union Switch & Signal — division of Westinghouse Air Brake Company. Formerly Myers was a sales engineer for general apparatus sales.

George Orr has been made southeastern district sales manager of Hill Hubbell and Company, division of General Paint Corporation. He was formerly associated with the Columbia Gas System.

A. W. Saunders has been named representative of Reed Roller Bit Company in England.

R. G. Kelly, vice president in charge of field operations for Halliburton Oil Well Cementing Company, has been elected a director of the company. He fills the vacancy created by the resignation of **Sam M. Gladney,** manager of Sun Oil Company's Dallas, Texas, division, who had been a Halliburton director for eight years.

Clyde W. Truxell, former works manager of the Detroit Diesel Engine Division of General Motors Corporation, has been appointed general manager of the division. He succeeds **Semon E. Knudsen,** who is now general manager of GM's Pontiac Motor Division.

Continental Supply Company has named two division managers and announced the retirement of another. **William D. Craig** will head the Arkansas-Louisiana-Mississippi-East Texas division with headquarters at Shreveport, Louisiana. The Rocky Mountain division manager will be **Glen R. Pike.** Craig is replacing **E. N. Wood,** who has retired.

Craig was formerly Rocky Mountain division manager. Pike was serving as assistant division manager under Craig. Headquarters for Pike will be at Casper, Wyoming.

T. A. Manhart, former senior partner of Manhart, Millison & Beebe, geophysical consultants, has been elected president of Century Electronics & Instruments, Inc.

T. A. Manhart

P. S. Bloudoff

Peter S. Bloudoff has been appointed to the newly created position of manager of product development for Fluid Packed Pump Company. He was formerly associated with Axelson Manufacturing Company.

R. M. Smith

George Orr

C. W. Truxell

John Holland Bannister has been appointed city sales representative at Midland, Texas, for Mission Manufacturing Company, while **John H. Brown** has been named city sales representative at Tulsa, Oklahoma.

Larry F. Drake has been appointed assistant sales manager of Welex Jet Services, Inc. Drake was previously Fort Worth, Texas, sales representative.

J. E. Brown has been named district manager for the Pawhuska, Oklahoma, district by Welex.

L. F. Drake

R. D. Goodall

R. D. Goodall has been advanced to general manager of the petroleum catalysts group of Davison Chemical Company, division of W. R. Grace & Company. He was formerly assistant vice president in marketing. **A. R. Worrall,** formerly manager of Davison's Curtis Bay Works, heads industrial chemicals, and **D. P. Barrett,** formerly sales manager of industrial chemicals, is in charge of rare earths.

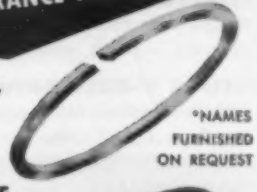
OVER 200
LEADING NATIONAL COMPANIES
NOW USE FRANCE RINGS

When you need Packings, Piston Rings or Valve Discs, France has over 55 years of experience that spells out:

M-A-X-I-M-U-M
P-E-R-F-O-R-M-A-N-C-E
and . . .
S-E-R-V-I-C-E

Check & SEE FOR YOURSELF!

*NAMES FURNISHED ON REQUEST



FRANCE PACKING CO.
PHILADELPHIA 15, PA.

SINCE 1898

For Full Information — Mail Coupon Now!
FRANCE PACKING CO.
PHILA. 15, PA.
Name .....
Title .....
Company .....
Address .....

Portable—easy operating

KWIK-MIX
6-S DANDIE®

SMOOTH TRAILING, easily spotted at job site, Kwik-Mix 6-S Dandie does on-the-spot mixing for concrete slabs, footings, and other widely-scattered jobs at drill sites, booster stations, around yards, refineries. Here are some of the operating advantages you get for one-man mixing and pouring:

SELECTIVE SKIP SHAKER engages automatically — speeds flow of aggregates and cement into the drum, can be set for shaking when skip is full, or partially empty. It is readily disengaged when no shaking action is needed.

AUTOMATIC WATER SYSTEM is accurate within a fraction of a pint. Valve opens automatically as skip is raised — water enters drum with aggregates at proper time to eliminate clogging. Folding action of blade-and-bucket drum double-mixes every batch.

TILTED FLOW-LINE DISCHARGE CHUTE with easy toggle-lever control reaches far into drum, catches all concrete — pours complete batch in 7 seconds.

MULTIPLE V-BELT DRIVE, high-carbon steel drum with double-thick roller paths, reduction gears enclosed in oil, and antifriction bearings throughout all assure dependable, trouble-free performance with this Kwik-Mix heavy-duty 6-S mixer.

OPTIONAL 6-S EQUIPMENT: distribution spout, auxiliary hoist, water pump, Batchmeter. Other sizes: 3½-S to 16-S Dandie concrete mixers. Also: 10 and 15 cu. ft. Moto-Bugs® with hopper, platform, fork lift attachments. See Kwik-Mix distributor, or write.

mail to: KWIK-MIX COMPANY Port Washington, Wisconsin

Send us bulletins on: ☐ 3½-S ☐ 6-S ☐ 11-S ☐ 16-S concrete mixers

NAME_____ TITLE_____

COMPANY_____ DIV._____

STREET_____

CITY_____ STATE_____

KM543 PE

BOOKS ★

Process Control Analysis, *by Millard H. Lajoy and E. Allen Baillif, published by Instruments Publishing Company, Inc., 845 Ridge Avenue, Pittsburgh, 12, Pennsylvania. Pages, 63. Price, $2.00.*

Authors have based their treatment on simple representation of the closed-loop system in terms of elementary resistance and capacitance elements, which give rise to ordinary, linear differential equations of fairly low order. These defining equations are then solved analytically, giving insight into the analog-computer and stability techniques that conclude the book. This work represents an essential first step for the control engineer or instrument man who wishes to extend his vision into the field of the frequency response of the closed-loop controlled system.

Chemical Process Industries, *by R. Norris Shreve, published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. Pages, 1004. Price, $11.50.*

As the second edition, this volume is a reference to methods used in the manufacture of chemicals and chemical products, broken down into unit processes and operations by convenient flow sheets. Ech of the chemical process industries is analyzed and described. Where figures were available, quantities of materials required to produce the finished product are given.

Covering the manufacture of chemicals themselves with full description of many manufacturing industries based on important chemical changes, this second edition contains illustrations, hundreds of tables and flow sheets with typical problems, to present an easy reference of each process, and the entire chemical process industry.

Process Engineering Economics, *by Herbert E. Schweyer, published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. Pages, 409. Price, $7.50.*

Both a text and reference for students, this book also serves as a reference for practicing engineers and other personnel in the process industries. Especially those in the fields of petroleum, chemical production, plastics, pharmaceuticals, mineral dressing and metal refining, food and chemurgicals processing, and ceramics manufacturing.

For engineers it offers ideas for effecting savings in design and operation. For students, it provides a composite coverage of theoretical engineering economy; accounting and finance data, including cost estimations and evaluations of the economic feasibility of operations; and economic balance in order to determine the optimum range of operations at lowest cost. The combination of theory with actual practice is distinctive.

An Encyclopedia of the Chemical Process Industries, by J. R. *Stewart, published by Chemical Publishing Company, Inc., 212 Fifth Avenue, New York, N. Y. Pages, 820. Price, $12.00.*

This volume, successor to the Stewart's Scientific Dictionary, fills a need, that of acquainting the researcher with brief data on innumerable trade named products; many "slang" and newly developed terms, with which many not closely connected with the specific branch of industry are not familiar. One drawback is absence of an index, but since all products, terms, methods, processes, etc., are listed alphabetically the need for an index is not serious. Much space is given to trade names and identifying expressions; tests and methods for identifying the analytical and chemical phases of the industry; special names and expressions, such as Elastolac for a shellac derivative; Newport Rosins, special rosins made by one company; Chrometrigraph, for measuring color directly in terms of the fundamentals hue, saturation and lightness, and so on. The length of explanation of terms varies greatly, ranging from 2-3 lines to a full page, the latter in rare instances. The volume will serve a need of the industry rather well.

Introduction to Microfossils, *by Daniel J. Jones, published by Harper & Brothers, 49 East 33rd Street, New York 16, New York. Pages, 406. Price, $6.50.*

Scope of the work in this volume is broad. The author describes the simplest and most practical methods of collecting, separating, and mounting microfossils. He describes and illustrates micropaleontological objects representing all major plant and animal groups, including such plant microfossils as spores and pollens, and fossil seeds and wood fragments.

Of special importance is his extensive discussion of the environmental significance of various microfossils, their stratigraphic distribution in sedimentary rocks, and the applications of such data to practical geological problems in economic and exploration geology. Over 1000 fossil forms are pictured.

JOHN WIGGINS' ANSWERS TO 8 QUESTIONS CAN HELP YOU SELECT A BETTER FLOATING ROOF SEAL

Are all floating roof seals the same? What about safety? Conservation? We asked John Wiggins, inventor of the floating roof and noted conservation authority, to answer questions most commonly asked about the new Wiggins Safety Seal.

1—**Q.** In the new Wiggins Safety Seal does any of the mechanism contact the liquid?

A. No. All metal working parts are out of the liquid away from corrosive vapors.

2—**Q.** Does the new "Weather Hood" provide longer fabric life?

A. Yes—the fabric is protected from the sun and other elements—lower temperature under the hood provides added conservation.

3—**Q.** In old style seals, rust and scale accumulate and shorten seal life. Does this happen with this seal?

A. The "Weather Hood" prevents rust and scale from depositing in the "seal loop"—thereby increasing seal life.

4—**Q.** Does the Wiggins Safety Seal prevent rim fires?

A. Yes—design of the seal virtually eliminates critical vapor spaces where air and vapor collect to form explosive mixtures. When exploded through controlled tests, the fabric was able to expand enough to contain the explosion without tearing.

5—**Q.** Is this seal safe for the storage of low vapor-pressure, low flash-point liquids such as jet fuels?

A. Yes, the design of the Wiggins Safety Seal reduces the danger area to a minimum so that it can be used in the storage of jet fuels with complete confidence.

6—**Q.** How does the Wiggins Safety Seal guarantee maximum protection against evaporation loss?

A. Air-vapor volume of the Safety Seal is less than 10% of the present volume for floating roof seals. This would eliminate most losses. In addition, the air-vapor space is shielded by a "Weather Hood". This area—the area that breathes—reduces losses to a minimum.

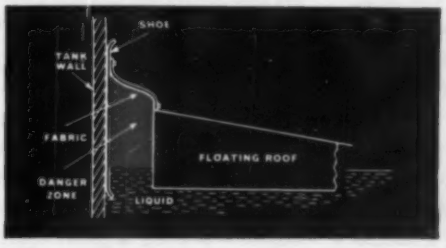
7—**Q.** Will the Wiggins Safety Seal save me money?

A. Yes—by eliminating losses due to thermal breathing, preventing rim fires, use of new longer-lived fabric, protecting the mechanism from liquid and corrosive vapors and permitting much longer periods of "in-service" operation.

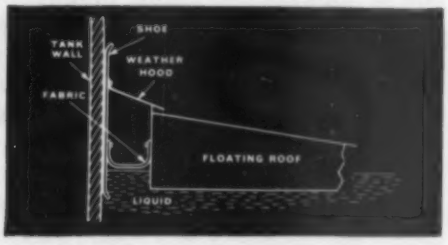
8—**Q.** Why have you put so much emphasis on the seal?

A. A floating roof is only as safe as its seal. With the new Wiggins Safety Seal, Wiggins floating roofs are in a class by themselves. Since General American makes all types of floating roofs, you can have the Wiggins Safety Seal on the roof that best meets your needs—whether it be the Wiggins Hidek*-Lodek* or Doubledek*.

*Patented



OLD
With the old type seal, the fabric is exposed to the sun's rays and explosive vapor collects in the large space between the liquid and the fabric; the mechanism is submerged in the liquid and exposed to corrosive vapors.



NEW
With the new Wiggins Safety Seal, vapor space under the circumferential fabric is reduced to a minimum. Ends spark fire hazards. Fabric is protected from the sun. Mechanism is out of liquid and corrosive vapor space.

To see why Wiggins Floating Roofs pay for themselves, write or call your General American sales engineer.

PLATE AND WELDING DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street, Chicago 90, Illinois

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Gulf Sales Engineer Thomas H. Chambers, Beaumont, Texas District (left) and R. W. Haney, Chief Engineer of the United Gas Pipe Line Company's Goodrich, Texas Compressor Station, inspect the company's six Ingersoll Rand 1320 H.P. K.V.G. engines. All these engines are lubricated with Gulf Security.

Lock out high maintenance costs in your gas transmission plants

with GULF SECURITY

Gulf Security's outstanding record in the lubrication of pipeline gas engine compressor units is your assurance of smooth, continuous operation. In scores of gas transmission plants this high quality straight mineral oil helps prevent operating troubles and contributes to low maintenance costs.

Gulf Security is a non-additive oil that does not cloud liquid filled lubricators of power cylinders, compressor cylinders, and packing glands. After years of operation with Gulf Security, cylinders and piston rings of both compressors and power assemblies show negligible wear, and its excellent oxidation stability helps prevent the formation of acid and resins in the crankcase system.

Make certain your units receive safe, effective lubrication protection—specify Gulf Security. And remember that Gulf provides the services of a trained, experienced petroleum expert—the Gulf Sales Engineer—to help you with any problem involving a petroleum product. Consult the telephone directory for the number of your nearest Gulf office.

GULF

Gulf Oil Corporation • Gulf Refining Company
1822 Gulf Building, Pittsburgh 30, Pa.

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

Oil Financing from the **FIRST** *in* **DALLAS**
goes where you go...

Russell Guffey on drilling site of Cooke County, Texas, operation. He is brother and partner of Roy Guffey, Roy Guffey Drilling Company, Dallas.

Specialized experience, organization, and resources to help you with practically any kind of need for "working money".

FIRST NATIONAL BANK IN DALLAS

Member Federal Deposit Insurance Corporation

put FIRST financing in your own oil future

1 in 1940

today... **1425** in operation

and **75** more under construction

a record of installations that is incomparable
just as all Petrochem-Isoflow Furnaces
are more economically desirable by any comparison.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE ... CAPACITY ... DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES:

Rawson & Co., *Houston* • Wm. H. Mason Co., *Tulsa* • Lester Oberholtz, *Los Angeles* • Faville-Levally, *Chicago* • D. D. Foster, *Pittsburgh* • Turbex, *Philadelphia* • Flagg, Brackett & Durgin, *Boston* • G. M. Wallace & Co., *Denver & Salt Lake City*

International Licensees and Representatives: SETEA-S.A. Comercial, Industrial, y de Estudios Tecnicos, *Buenos Aires, Argentina* • Industrial Provendora, *Caracas, Venezuela* • Societe Anonyme Huertey, *Paris, France* • Societe Anonyme Belge, *Liege, Belgium* • Huertey Italiana S.P.A., *Milan, Italy* • Birwelco Ltd., *Birmingham, England*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

LQ600 VALVES

• NO LEAKAGE • NO EROSION
• NO WIRE DRAWING
. . . In 100,000 applications and 5 years of tests

Famous LQ600 Bronze Valves, with revolutionary Brinalloy seats and discs, now solve maintenance problems in a new wider range of services!

The lower pressure LQ600-150 made valve history during five years of cost-cutting use in a big variety of installations, ranging from "normal" to "exceptionally severe."

Now the higher pressure LQ600-200 offers all the same proved features — plus a stronger body and bonnet of exclusive Lunkenheimer S-1 Bronze. It has a total temperature rating of 550°F.

It will pay you to specify and install LQ600 in your toughest 150 and 200 lb. services. New Brinalloy seats and discs resist wear and corrosion to an amazing degree — far greater than 500 Brinell Stainless Steel . . . even outwear case hardened Stainless Steel exceeding 1000 Brinell. The flat seats and discs are micro-optically lapped to a perfect fit — and brazed in to stay.

Call your Lunkenheimer distributor or write The Lunkenheimer Company, Box 360, Cincinnati 14, Ohio.

BRONZE • IRON • STEEL • PVC

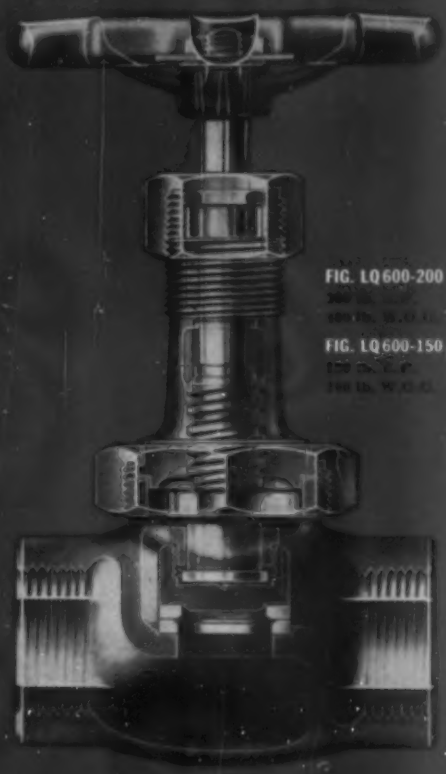


FIG. LQ600-200
300 lb. S.P.
400 lb. W.O.G.

FIG. LQ600-150
150 lb. S.P.
300 lb. W.O.G.

NOW AVAILABLE FOR
200 LB. S.P. 400 LB. W.O.G. and
150 LB. S.P. 300 LB. W.O.G.
APPLICATIONS

BRINALLOY* SEATS AND DISCS

*Patented Alloy —TM Reg.

LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

L-556-24

You and I both belong here! After all, there wouldn't *be* any busy highways without us! I'm a secretary to a land man. You may be anything from a driller to a board chairman. Between us we helped keep over 50 million cars on the road last year. People used them for fun, convenience, business. Remember that, the next time you hear unfair criticism of us oilmen. We've got lots of facts on our side. Let's speak up and make the facts known! **SHELL OIL COMPANY**

SPECIALIZED PETROLEUM PROCESSING

for producers and refiners

PETRECO ELECTRIC DEHYDRATION

Petreco electric dehydration is an automatically controlled method for reducing the B.S. and W. content of crude oil to pipe line specifications. It is particularly adaptable for large central plant dehydrating systems and also is highly effective on low gravity crudes.

PETRECO SEDIMENT SEPARATION

Where producers utilize sub-surface hydraulic production pumps, it is essential that the power oil be clean, dry and free from fines, sediment, etc. Petreco Electric Sediment Separation removes such impurities from crude oil and delivers clean power oil.

PETRECO ELECTRIC DESALTING

Petreco pioneered electric desalting and is the recognized leader in this field. Petreco offers a choice of desalting vessels, to better handle varying volumes of crude. In every refinery where Petreco desalters have been installed, salt difficulties have been stopped.

PETRECO ELECTROFINING

Electrofining is a Petreco development and offers a revolutionary method for caustic washing, acid contacting, doctor treating and nitrogen base removal. Electrofining usually is a single-unit, one-pass, automatically controlled, continuous process.

PETRECO — BENDER SWEETENING

The Petreco Bender Process is utilized for sweetening gasoline, kerosine, jet fuel and No. 2 fuel. Sweetening is effected by converting mercaptans to disulphide by oxidation. The chemical cost is low, throughput rates are high, and catalyst can be rejuvenated at the plant.

PETRECO ELECTRIC LUBE-OIL TREATING

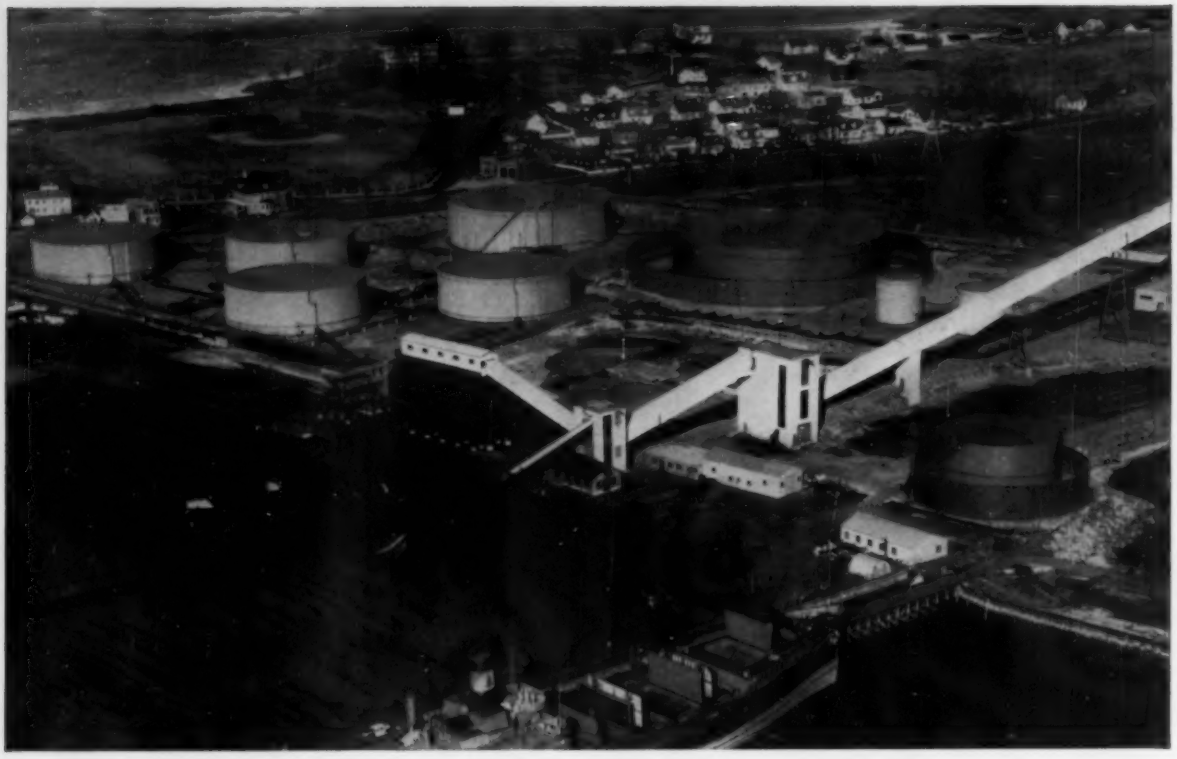
Petreco Lube Oil Treating provides continuous, automatically controlled acid treatment for lube oils and similar stocks. Treating takes place in a closed system, requiring much less tankage than conventional acid treaters. It saves acid, time, space and guesswork.

PETRECO®

A DIVISION OF PETROLITE CORPORATION

3202 South Wayside Drive, Houston 1, Texas • 1390 East Burnett Street, Long Beach 6, California

APC-9



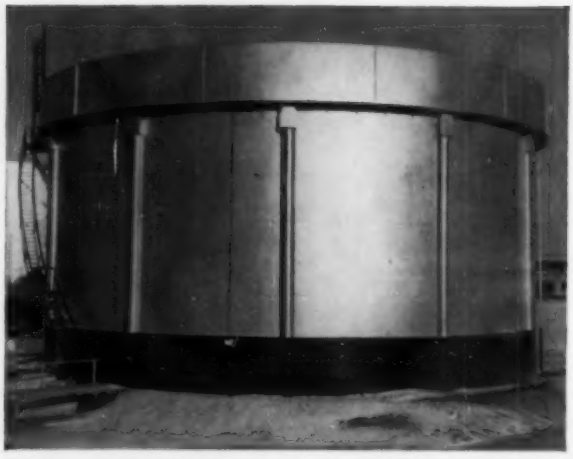
Big Tanks at Salem Harbor

Here is one of New England's largest, most up-to-date oil storage installations—Salem Harbor Terminal in Salem, Mass. Operated by Pocahontas Fuel Company, the terminal has a capacity of over 700,000 bbl of No. 2 and Bunker "C" fuel oils, plus large stocks of coal for such industrial users as New England Electric System's large, modern steam electric plant just beyond the picture at right.

Modern coastwise tankers berth at the deep-water dock and discharge their cargoes at a rate of 8,000 bph. Tank trucks are loaded fast at high-speed racks. This terminal can service 500 to 600 trucks per day on a 'round-the-clock schedule.

The seven large storage tanks you see here, all fabricated and erected by Bethlehem, total 700,000 bbl of storage capacity. One of them measures 200 ft in diameter by 40 ft high and has a capacity of over 220,000 bbl of oil. The others vary from 35,000 bbl to 143,000 bbl.

Many leading terminals throughout the East include tanks of Bethlehem design and construction. Floating-roof tanks (pontoon, double-deck and pan-type roofs) as well as lifter-roof and cone-roof types. We build them all. We'd be happy to give you further information. Just call or write the Bethlehem sales office nearest you.



PREVENTS BREATHING LOSSES. The Bethlehem lifter-roof tank is engineered like a single-lift gas holder. The roof rises smoothly in the heat of day; lowers at night. There's practically no loss of product. Designed to withstand weather extremes. The 54,000-bbl tank shown here is in service at Pocahontas' South Portland, Me., terminal.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Handiest Locations in PITTSBURGH

Hotel Pittsburgher
PITTSBURGH, PA.
Diamond Street below Grant

Right in the heart of the Golden Triangle—Hotel Pittsburgher

400 outside rooms with bath. Large-screen television and radio at no extra charge in every room. Air conditioning. Finest dining room. *ATlantic 1-6970*

Hotel Pittsburgher MOTEL

Opposite Greater Pittsburgh Airport on Airport Parkway west. 56 air-conditioned rooms with large-screen television at no extra charge. Tile bath. Private phone. Restaurant facilities. Courtesy car to and from airport. *AMherst 4-5152*

a Knott Hotel

JOSEPH F. DUDDY, GEN. MGR.

PRECISION THREADING For The BIG Ones

Model 2 and 2BR

GEARED PIPE THREADERS

Here's true accuracy with the exclusive TOLEDO receding die principle—best for deep sealing, smooth tapering pipe threads for 2½ to 4" pipe or conduit. Cuts standard, over or undersize threads. Excellent for steel, wrought iron, brass, copper or cast iron pipe. Simple construction—easy to set up and use. Take our tip—it's tops.

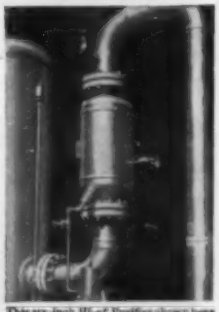
Lightweight **#78** POWER DRIVE

WORKS AS GOOD AS IT LOOKS

This 75 lbs. power vise makes threading, cutting and reaming a fast, simplified operation when out on the job. Carry it practically anywhere. Sturdy tripod legs, self-centering jaws and quick-acting wrenchless chuck. Polished aluminum housing—dependable geared action—precision construction throughout. Get your order in early for this fast-moving profit maker.

REDUCE GAS SCRUBBER COSTS UP TO 500%

This new method of scrubbing gas saves up to 500% over conventional methods! Occupying only ⅛ the space of other type scrubbers, Hi-eF line purifiers recover virtually 100% of the liquid present in butane, methane, propane and other hydrocarbon gases. Absolutely no danger of carryover. Requires no maintenance . . . has no moving parts. Scrubbing is accomplished without the use of filters or screens of any type. Mail coupon for free bulletin describing these money-saving devices today!



This six-inch Hi-eF Purifier shown here at the Sweetie-Peck Station of the El Paso Natural Gas Company is only 54" long and 16" in Dia., less than 20 per cent the size of conventional scrubbers.

GET FULL DETAILS FREE

ANDERSON Hi-eF PURIFIERS

THE V. D. ANDERSON COMPANY
Division of International Basic Economy Corporation
1951 W. 96th St. • Cleveland 2, Ohio

Without obligation send us your new Bulletin 710.

Name _____ *Title* _____

Company _____

Address _____

City _____ *State* _____

TOLEDO PIPE WRENCHES

The wrench for everyday work load punishment. Unconditionally guaranteed TOLEDO quality. Sturdy frame and jaw, positive grip, quick easy adjustment. The wrench for your heavy-duty jobs. See it today. Try it out.

THE TOLEDO PIPE THREADING MACHINE CO. • TOLEDO 4, OHIO

BUILDERS OF THE WORLD'S FINEST PIPE TOOLS

TOLEDO

PIPE THREADERS • PIPE WRENCHES • PIPE MACHINES

International Power Unit

ordered, equipped, delivered and

LOS ANGELES, CALIF. An International Power Unit was ordered, equipped to meet customer's specifications, delivered, and "on pump" in a short, *perhaps record-breaking, 5½ hours, here, recently.*

The complete transaction took place when one of Atlantic Oil Company's wells on Terminal Island in the Los Angeles Harbor District "came in" late on the evening before. The power unit was ordered from a nearby International Power Unit Distributor, at 9:30 a.m. The unit was ready for delivery from the distributor at 11:30, after specified equipment had been added.

At 12:10 p.m., the unit arrived at the well site, 12 miles away. Final installation, including a running check on natural gas, required only three hours. Then the unit was on duty at 3:00 p.m....a mere 5½ hours from the time of the phone call.

The following pictures tell the complete story:

Phone call for the International U-164 is made at 9:30 a.m., to distributor sales manager.

Meeting installation requirements, distributor mechanic adds equipment for low-cost natural gas pumping of 3700-foot well.

Engine is lowered onto foundation, where mechanics quickly go to work bolting it down.

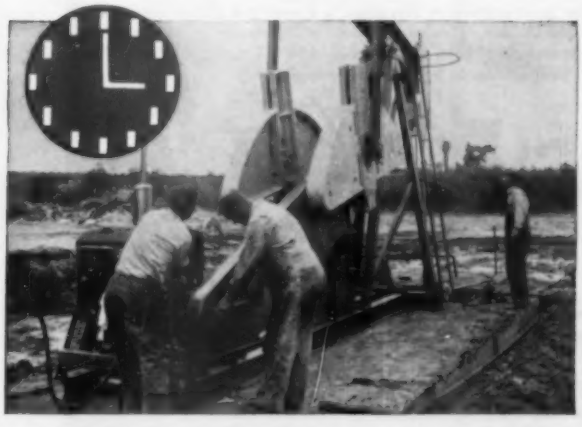
With engine in place, distributor representative and customer production foreman check installation before proceeding with pulley, belt, and guard.

"ON PUMP" in 5½ hours!

...it's typical of the on-the-spot oil field service you get from your International Distributor!

Two hours after call, engine, ready for duty, is loaded onto distributor's waiting service truck.

Well site, 12 miles away, was reached at 12:10 p.m., and engine is quickly unloaded.



A little before 3 p.m., mechanics make final adjustments, put belt guard in place. Engine begins delivering oil at 3 p.m., 5½ hours after first phone call!

On-the-spot service like this is typical of "on-their-toes" International Distributors you'll find near your oil or gas jobs. Your International Power Unit Distributor offers a complete line of International engines—famous for long life, dependability, and next-to-nothing maintenance costs—plus complete parts and service. Your International Construction Equipment distributors offer you 7 job-proved International crawlers ranging from 41.5 to 161 dhp, with a wide choice of attachments.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Crawler and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

The One Pipe Wrench that Out-performs and Out-lasts all others...

Genuine Heavy-Duty RIDGID

This pipe wrench does its job so well that millions of users swear by it.
It's extra strong and safe—sure jaw action aided by new patented hookjaw suspension.

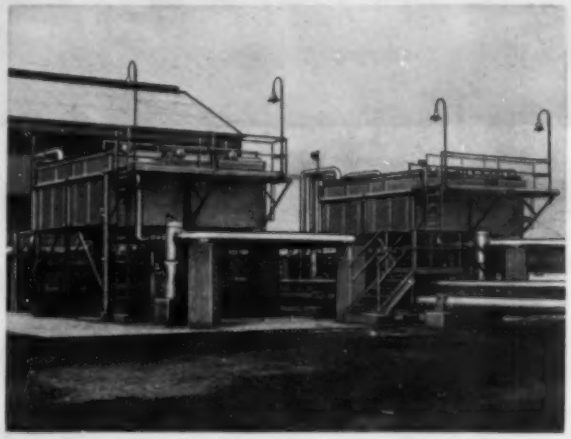
Grips pipe or conduit instantly, no slip, no lock. Rugged comfort-grip I-beam handle ...handy pipe scale and easy-spin adjusting nut. Every wrench factory-tested, 6" to 60" ...to assure you *most* for your money. Buy RIDGIDs at your Supply House!

RIDGID
Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U.S.A.

Young Engineering Talent

Shows Results in Actual Use at Illinois Gas Storage Field



Young "H-C" UNITS . . .

cool natural gas for underground storage

Hundreds of feet below Herscher, Illinois, lies a geological dome used to store natural gas for Chicago and 24 other gas utility companies in a six-state area. Before gas from the pipelines can be injected into the underground reservoir, it is cooled by two Young "H-C" units to eliminate the danger of cracking or warping the well cementing and disturbing the underground formation. Young "H-C" horizontal core units combine the *efficiency* of vertical air discharge, the *economy* of compact design, and the *versatility* of multiple unit combinations.

More Young "H-C" Units used in desulphurization of vent gas

Also in operation at Herscher is a vent gas gathering system which gathers, desulphurs and re-injects into the reservoir escaping gas. Here, too, Young "H-C" Units cool the gas to the proper degree before it is re-injected.

Write Dept. 216-J for FREE Catalog

Put Young Talent to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.

HC is a registered trademark.

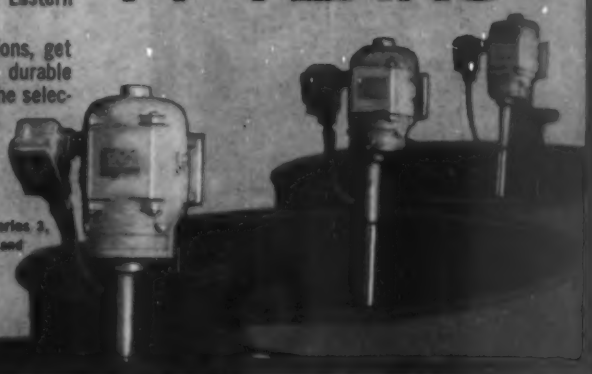
Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY
Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.
Executive Office: Racine, Wisconsin. Plants at Racine, Wisconsin, Mattoon, Illinois.

Back in 1942 the new synthetic rubber program was of urgent importance to the war effort. Naugatuck Chemical Company, Division of U.S. Rubber Co., developed processes that included fluid mixing applications. Many of Naugatuck's top-entering and portable mixers were engineered and manufactured by Eastern Industries specifically for these processes.

After fourteen years of hard, continuous service, these Eastern Mixers continue proving their built-in **reliability.**

If you have a process entailing critical operating conditions, get a long-term guarantee on your investment by selecting durable Eastern Mixers. Eastern offers engineering assistance in the selection of proper mixers from the complete Eastern line.

CONTINUOUS SERVICE . . . 14 YEARS



Eastern
INDUSTRIES, INC.
Mixer Division
Regent Street
Norwalk, Conn.

Write for Catalog Series 3, containing product and engineering data.

PORTABLE MIXERS

Various models offer a choice of speeds and H.P. dependent upon the consistencies of fluids. All models are available with shafts and propellers of various alloys. Single and dual propellers, and a wide choice of motors give flexibility to handle the most critical of operating conditions.

TOP & SIDE ENTERING MIXERS

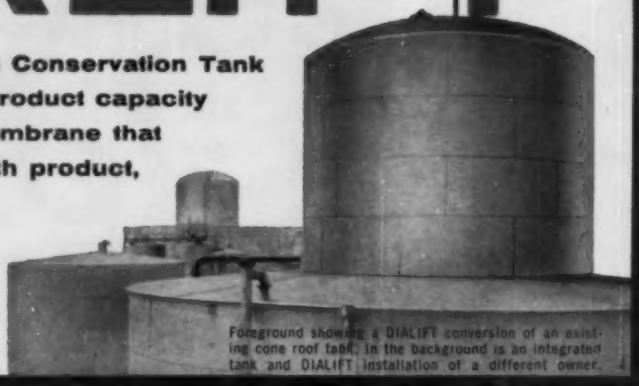
Heavy-duty models cover the range from ¼ to 30 H.P., at speeds from 280 to 1725 R.P.M. Versatile in design . . . rugged in performance, these mixers offer a wide choice in mounting arrangements and motors. All side entering models are available with stuffing boxes which can be repacked with a full tank.

TURBINE MIXERS

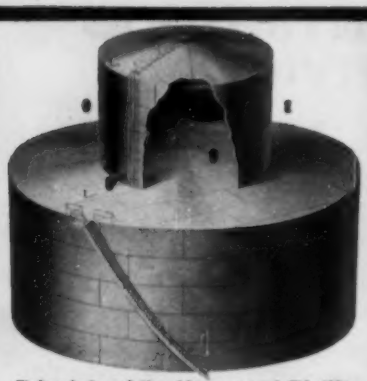
Many of the Eastern Turbine applications include blending, dissolving and heat transfer. A variety of motor mounts and stuffing boxes available within a H.P. range of ¼ to 40, add flexibility to the Eastern line.

The HAMMOND
DIALIFT

The ONLY membrane type Conservation Tank with full-rated vapor and product capacity AT ALL TIMES, with a membrane that cannot come in contact with product, vapor space that can be isolated for inspection and maintenance without taking product storage tank out of service.



Foreground showing a DIALIFT conversion of an existing cone roof tank. In the background is an integrated tank and DIALIFT installation of a different owner.



Principle of the Hammond Dialift

A— DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.
B— Vapor passes to and from tank and DIALIFT through simple elbow connection.
C— DIALIFT and tank have full-rated capacity.
D— Membrane can't come in contact with product.
E— DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

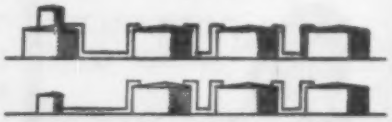
The most efficient and economical vapor conservation system for new or old tanks.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation: —Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a product tank for vapor conservation for one or a number of tanks.

The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.

DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.



The HAMMOND dialift eliminates breathing loss and reduces filling loss

Other HAMMOND Bulletins describe these individual types of tanks: Floating Roof, Diaflote,* Vaporlift, Field Erected Underground, Elevated Water Tanks and Standpipes, Low Pressure, Bulk Storage.

Write for Dialift Catalog 55DL

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices:

BOSTON 10, MASS. • NEW YORK 20, N. Y. • CINCINNATI 2, OHIO • CHICAGO 3, ILL. • WARREN, PA. BRISTOL, PA. • ARLINGTON, VA. • GREENVILLE, S. C. • BIRMINGHAM, ALA. • SAGINAW, MICH. SAPULPA, OKLA. • PROVO, UTAH • CASPER, WYO. • LOS ANGELES 57, CALIF. • HAVANA • MEXICO CITY "TIPSA," BUENOS AIRES • CAIRO, EGYPT • PORT-AU-PRINCE, HAITI • LIMA, PERU

Licensees: CALIFORNIA, CANADA, ENGLAND, BELGIUM, GERMANY, ITALY, FRANCE, JAPAN

DRILLING ENGINEERS

Foreign Drilling Operations

Oilwell Drilling Contractor has immediate openings for Drilling Engineers in Sicily and Africa. *Liberal salary and bonus.* Box 180, c/o *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

OPERATING ENGINEER

NEW YORK OFFICE

To assist in supervising office and field and domestic and foreign activities of the Operating Department. Challenging opportunity for graduate chemical or mechanical engineer with minimum five years petroleum refining experience, preferably with contracting engineering firm.

Please airmail confidential verifiable chronological resume, including salary history, to

PERSONNEL DEPARTMENT

HYDROCARBON RESEARCH, INC.

115 Broadway **New York 6, N. Y.**

PLANT ENGINEERS

(Natural Gasoline)

Permanent positions with excellent advancement opportunities with an expanding organization for Process, Design and Project Engineers. Degree in petroleum, mechanical or chemical engineering and three to eight years' experience required. Starting salary attractively commensurate with background and experience. *All replies confidential.* Send resume to:

WARREN PETROLEUM CORPORATION
Box 1589
Tulsa 2, Oklahoma
ATTENTION: R. L. Lane or C. C. McKee

RETREAT

(Year Around)

Hill Country, twelve large units. Permanent structures. Some housekeeping. Approximately two acres, adjacent park on lake. Fishing, boating, swimming, hunting. Also large residence or club house, on two important highways. Real bargain. Write Box 179, c/o *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas.

PETROLEUM ENGINEERS

(South America)

Graduate engineers with experience in drilling, production, reservoir and equipment. Working knowledge of Spanish desirable but not essential.

LUBRICATION ENGINEERS

(West Africa)

Mechanical Engineer's degree and experience in lubrication and petroleum products. Fluent French not essential but working knowledge desirable.

OPERATIONS SUPERVISOR

(West Africa)

Experienced all phases construction engineering concerning marketing petroleum products, i.e., appropriations, terminal layout and maintenance. M.E. or C.E. degree desirable but not essential. Working knowledge French essential.

Liberal Employe Benefit Plans
Salary commensurate with experience

Forward resume of
education and experience to

THE TEXAS COMPANY
Foreign Personnel Office
135 East 42nd Street
New York 17, N. Y.

PETROLEUM ENGINEERS

Experienced graduate engineers for immediate openings in Saudi Arabia and New York City. For engineering work in development, production, drilling, process, and oil and gas engineering on primary and secondary recovery problems.

RESERVOIR FLUID ANALYST

With degree in Physical Chemistry or Chemical Engineering plus 5 years' petroleum production engineering which should include 2 years' study of reservoir fluid behavior.

Salaries commensurate with training and experience. Write outlining personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 117

ARABIAN-AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

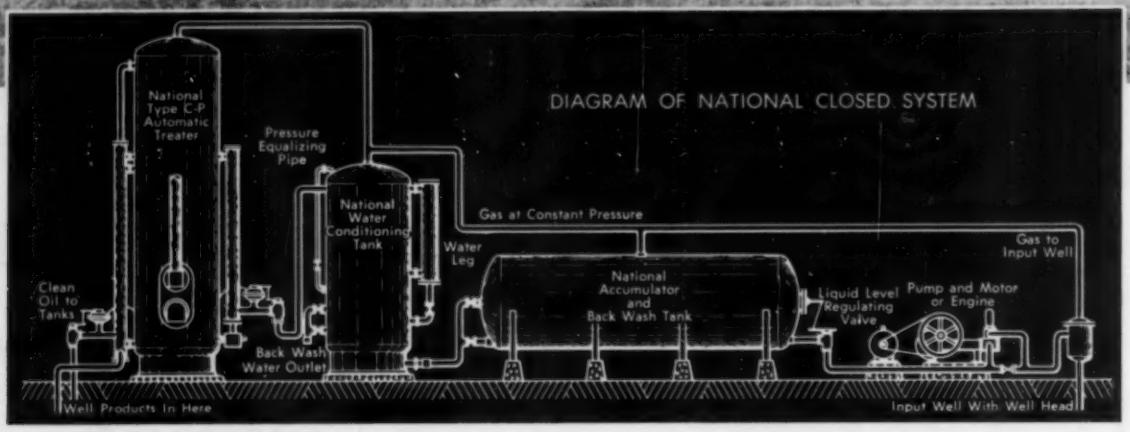


DIAGRAM OF NATIONAL CLOSED SYSTEM
National Type C-P Automatic Treater
Pressure Equalizing Pipe
National Water Conditioning Tank
Gas at Constant Pressure
Water Leg
Gas to Input Well
Clean Oil to Tanks
National Accumulator and Back Wash Tank
Liquid Level Regulating Valve
Pump and Motor or Engine
Back Wash Water Outlet
Well Products In Here
Input Well With Well Head

NATIONAL CLOSED WATER DISPOSAL SYSTEMS

. . . used for Pressure Maintenance

National Water Disposal Unit, Wesson Field, near Stephens, Arkansas.

2 10′ x 20′ horizontal accumulator and backwash
2 10′ x 20′ vertical conditioners
1 10′ x 5′ filter
1 2IF separator (used as gas scrubber)

NATIONAL ALL THE WAY!

Field opened January, 1946 — Bottom Hole Pressure 1299 PSI.

On July 1, 1948, BHP had dropped to 412 PSI. Water injection began September 1, 1948.

To date, 36,758,358 bbls. of water have been returned to the formation and BOTTOM HOLE PRESSURE IS NOW 1357 PSI — 58 PSI GREATER THAN ORIGINAL PRESSURE.

Oil Production to date — 17,571,999 bbls.

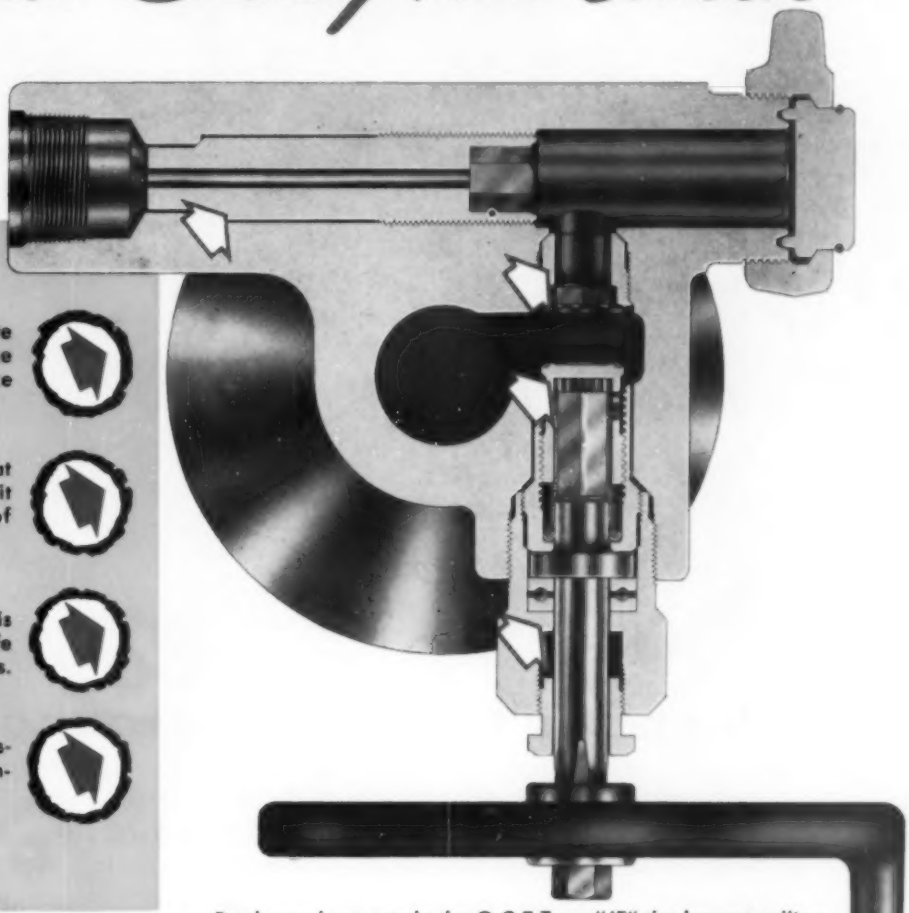
Our Engineering Department welcomes inquiries concerning your water disposal problems.

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

Here's why the O·C·T "JE" is the *Largest Selling Flow Control*



Body can accommodate any size positive choke to 1" or adjustable choke up to ¾" opening.

Hard faced 1" valve seat is replaceable to permit complete renewal of valve in five minutes.

True valve-type gate is hard-faced for long life under severe conditions.

Ball thrust bearing assures easy operation under highest pressures.

Producers have made the O-C-T Type "JE" the largest selling flow control because it helps them reduce both first cost and maintenance expense. It is the only flow control on the market that gives you the advantage of both a choke and a true valve-type gate assembly and seating arrangement.

The O-C-T type "JE" Flow Control is available through any Christmas tree manufacturer or through more than 700 supply store locations.

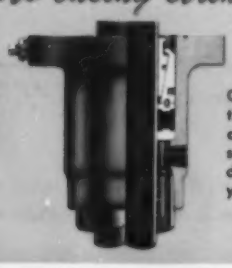
O·C·T

OIL CENTER TOOL CO.

P. O. Box 3091, Houston, Texas

Export Representatives: Sterling Areas — Le Grand, Sutcliff & Gell, Ltd., Rochester, Kent, England. South America—East West Oiltools, C. A., Del Lago Hotel, Maracaibo, Venezuela. Address Export Inquiries for All Other Countries to P. O. Box 3091, Houston, Texas.

No casing string too long . . .



The O-C-T C-19 Casing head can support the longest strings with complete safety. It is the safest, most economical deep well casing head you can buy.

"y' just don't push me around—see!"

LANE-WELLS HYDRAULIC HOLD DOWN TOOL HOLDS PACKERS IN PLACE AGAINST 6,000 PSI DIFFERENTIAL PRESSURE

Small though it is, this ingenious new Lane-Wells tool has proved its value in some right tough situations. It's actuated by hydraulic pressure — the higher the pressure, the harder its 24 pistons push out, the tighter its 96 hardened points grip the casing.

While it's rated to hold against 6,000 psi, our tests indicate holding power higher than that. Field tests on acidizing jobs, fracturing jobs, high-pressure formation testing, straddle packer assemblies and the like haven't been able to budge the packer assemblies that used the Lane-Wells Hydraulic Hold Down Tool. Every time, the tool has held, yet released easily when pressure was slacked off. Just to make sure, the Hydraulic Hold Down Tool has been made as corrosion-resistant as possible by plating it with non-porous nickel plate.

If you have problems of high pressure, include a Lane-Wells Hydraulic Hold Down Tool in your packer assemblies, whomp up the pressure, and relax—the Hold Down Tool won't!

Tomorrow's Tools—Today!®

LANE WELLS COMPANY

Los Angeles • Houston • Oklahoma City • Lane-Wells Canadian Co. in Canada • Petro-Tech Service Co. in Venezuela

General Offices, Export Office and Plant • 5610 So. Soto St. • Los Angeles 58, California

Of Things To Come . . . In Oil

CALIFORNIA OFFSHORE DRILLING — on a large scale basis — will not get underway until the end of this year. Heavy drilling equipment strength is growing, although current activity is centering on exploratory coring and confirmation work. Largest barge yet scheduled for West Coast work is now on its way up the California coastline for use by Monterey, Seaboard and Humble Oil companies.

STEEL MANUFACTURING GOALS are soon to be reset by the Defense Mobilization Board, vitally affecting the availability of oil country tubular goods. If added steel capacity is needed, ODM Director Flemming will immediately authorize new fast tax write-offs for new plants. One plant, seeking tax aid, would be built in the steel shortage-stricken Southwest.

NAVAJO INDIAN LEASING CONTRACT with Delhi-Taylor Oil Company may get reconsideration. Tribal Council Chairman Paul Jones has appealed to Interior Department officials, who rejected the pact, indicating that insufficient attention was given the leasing agreement involving 5,363,000 acres of reservation lands. An alternate plan offering competitive lease bidding among companies may be the solution.

WATER POLLUTION IN TEXAS by oilfield operations will come in for special study come next January when Texas legislature meets. Oil operators have formed the Texas Petroleum Industry Water Committee, headed by Bruce Street of Graham, Texas, to work closely with the problem. TPIWC already recommended that salt water pollution in the oilfields be administered by the Texas Railroad Commission.

ATOM MOTOR FUEL LONG WAY OFF, according to Kenneth Davis, director of reactor development of the Atomic Energy Commission. Nuclear energy can do little to replace other fuels for 15 or 20 years, and is not likely to be used for motor fuels anyway, he emphasized.

RIG ACTIVITY TO INCREASE during remaining months this year . . . although rig count now nearly 200 below comparable period last year. Resumption of steel production will help, plus normal increase in fall.

What do you want in a drilling mud that . . .

BLACK MAGIC

doesn't have?

NO HARMFUL FILTRATES?—BLACK MAGIC is made with refined oil. It can pick up as much as 25% or more water by volume without losing water into the formation. Water content is held tightly in emulsified form. API Filtrate loss is zero for sixty minutes. Highest return permeability of any drilling mud!

EXCELLENT PLASTERING PROPERTIES—BLACK MAGIC maintains a slick hole, lays down an extremely thin wall cake and reduces torque through drill stem lubrication. BLACK MAGIC's thin mud cake disintegrates in crude oil when well is completed.

CORES AS NATURE MADE THEM?—BLACK MAGIC offers excellent core recovery even in the softest formations. Connate water is not flushed out and core analysis gives true values. In unbiased tests, return permeability is as high as 98% when BLACK MAGIC is used.

GREATER VERSATILITY?—BLACK MAGIC can be weighted as desired—from 7.5 lbs/gal to 21.4 lbs/gal—yet still retains a readily pumpable viscosity. BLACK MAGIC is unaffected by salt, hydrogen sulfide, gypsum, anhydrite or any other calcium or magnesium ions that adversely affect other drilling fluids. In the deepest, hottest holes, BLACK MAGIC's superior properties are really outstanding. BLACK MAGIC's small diesel oil filtrate is compatible with formation crudes and thus BLACK MAGIC does not block off return permeability. BLACK MAGIC is the most ideal workover fluid available!

LOW COST MAINTENANCE?—BLACK MAGIC is easy and inexpensive to regenerate with OBI chemicals. Systems used as long as eight years are still in operation. BLACK MAGIC remains stable under the most severe hole conditions. It can be stored indefinitely. Extremely high weights are maintained at minimum cost since formations drilled do not dilute this mud.

Of course, you want all these qualities in your drilling mud. The way to be sure you get them ALL, *plus* other exclusive advantages, is to specify BLACK MAGIC . . . the first successful oil base mud commercially available . . . backed by the broadest, longest success record of them all.

Call your nearest OBI Representative. He has complete data for you.

OBI PRODUCTS

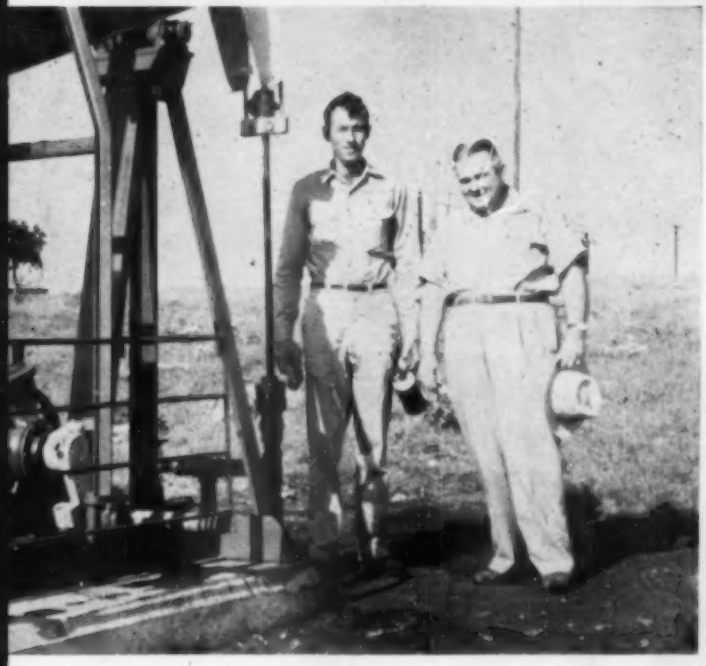
OIL BASE, INC.

PLANTS IN: Houston • Odessa • Duncan • Bakersfield • Compton
BRANCHES IN: Houston • Odessa • Corpus Christi • Oklahoma City • Duncan • Lafayette • Harvey • Bakersfield • Long Beach • Ventura
REPRESENTATIVES IN: Mexico City • Caracas • Lima • Bogota • Calgary • Paris. CABLE ADDRESS: OBI

AXELSON PICTORIAL

SWAMPED. Curly Robin, Pumper for the California Company in the Plumb Bob Field, Lafayette district, Louisiana, gives the stuffing box a shot of grease on the St. Martin Land Company #1. An Axelson RL Plunger Pump (2½ x 1¾ x 15) pumps 156 B/D of 37 gravity oil from 5,100 ft. Curly visits his swampland wells by boat.

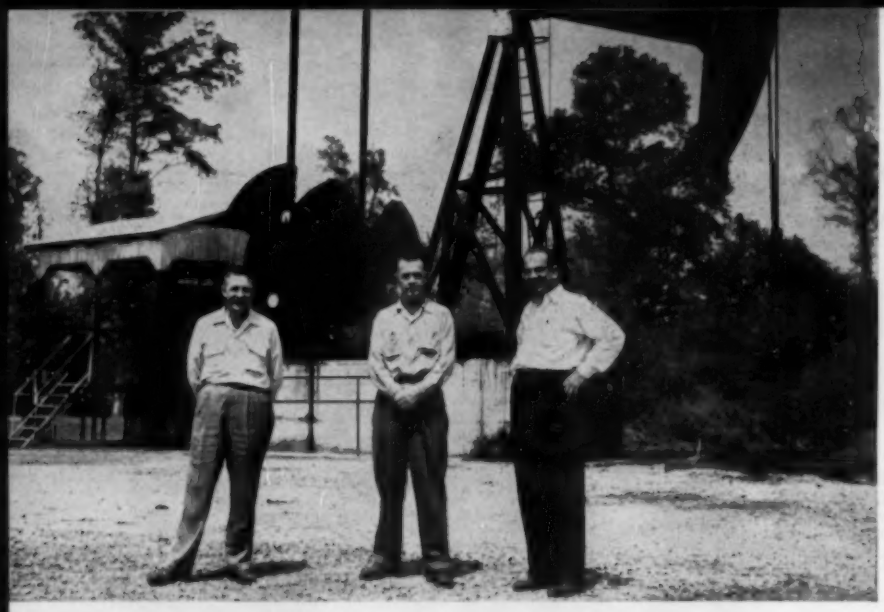
COSTS CUT. Don Williams (left), Pumper for Seneca Oil Company, and Jack Felton, Axelson Representative, beside the No. 23 Linn in the T.C.U. Field, Cook County, Texas. This well was pulled on an average of twice a month until an Axelson 1¼" Acme Pump with Duax Liners was installed September 1955. It has been running continuously ever since, 24 hours a day, and has not been touched. Seven other wells were converted to Axelson Acme Pumps and *pulling costs were cut from $475 to $75 per month.*



HEARTBEAT. Checking the pulse is Frank Roberts, Pumper for National Associated Petroleum Company, on one of the company's 60 pumping wells in the Whitetail Field, Osage County, Oklahoma. All of these wells are equipped with Axelson 1½" Sure Seal Pumps and Axelson ⅝" Rods, and pump from the Mississippi Lime at 2050 ft.

AXELSON

USI



AXELSON

THE DEEPEST. An Axelson 1¼" bore pump with hardened cast iron liners and 60" heavy chrome-plated stainless steel plunger, pumps 20 BPD of 38 gravity oil from 10,178 ft. This is the deepest pumping well in the Mallalieu Field, Brookhaven, Mississippi. A 3-step Axelson #59 sucker rod string actuates the pump. (l. to r.) Harold Long, J & L Store Manager, Brookhaven; Pat Moran, Production Foreman, The California Company (and Yogi Berra fan); Truman Reader, Axelson Representative.

GOOD RECORD. In front of Ashland Oil & Refining Company's #1 Crouch at Luther, Oklahoma, is Tom Charter, Pumper, and Charles Chandler, Chief Gauger. This well was completely Axelson equipped on July 1, 1955, with a Hydrax pumping unit, Axelson sucker rods and Axelson deepwell pump. It lifts sweet oil (39 gravity) from the Red Fork Sand at 5,062'. *To date no repairs have been necessary on any of the equipment.*

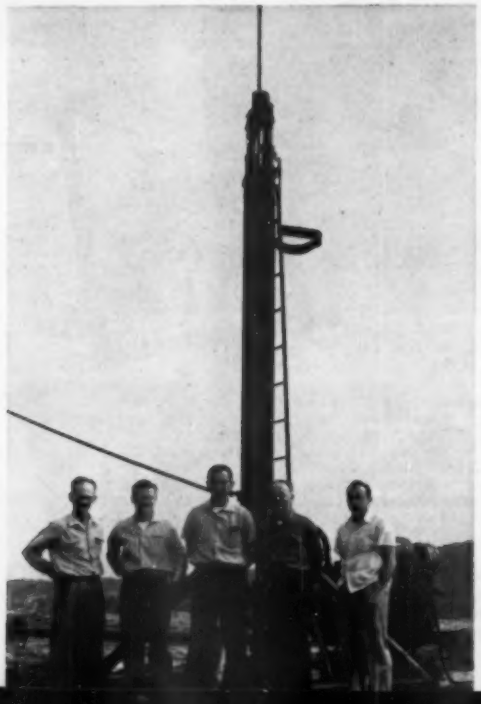
ON REQUEST. Axelson has a limited supply of "Factorules", a slide rule for calculating production, loads and other factors in pumping wells. It provides a quick means for estimating production and efficiency of wells produced by sub-surface reciprocating pumps and sucker rods. A Factorule complete with instructions will be mailed free of charge when requested on your company letterhead. Write to Dept. P.

NEW FIELD. B. L. Coggins, Production Foreman for McNeish & Grallap, looks after 28 producers on the Muller Lease in the Cleveland Sand Field, Kay County, Oklahoma. This is a relatively new field, first discovery was 1954. The 14 wells on the pump *(all equipped with Axelson rods and pumps)* produce from the Cleveland Sand at 3,150'. Pressure drop is rapid and it is expected the 14 flowing wells will soon go on pump, too. "When they do, they'll be outfitted with Axelson equipment. You can be sure of that!" B. L. states.

AXELSON PICTORIAL

OKLAHOMA'S FIRST. This is the Nellie Johnstone #1 located in the city park at Bartlesville, Oklahoma. Completed April 15, 1897, it was the *first commercial oil well* in Oklahoma. It produced until about 2 years ago from 1900 ft. and is now plugged. Reading the inscription is M. J. Bohnsack, Salesman at the Jones & Laughlin Store at Bartlesville. This was the *first supply store west of the Mississippi*. J. & L. is distributor for Axelson pumps and sucker rods in all oil producing areas east of California.

TWINS. Ray Postier, Production Pumper of P. G. Lake, Inc., set up this dual job on the Cogswell Heirs Well #2, Garfield County, Oklahoma. Axelson Pumps and Rods are pumping both pays; a 1½" Axelson insert pump produces the Marshall sand at 6150' while an Axelson 1¼" Axelson pump produces the Meisner sand at 5950'. An Axelson two-step rod string composed of 45% ¾" rods and 55% ⅞" rods is used with both pumps.

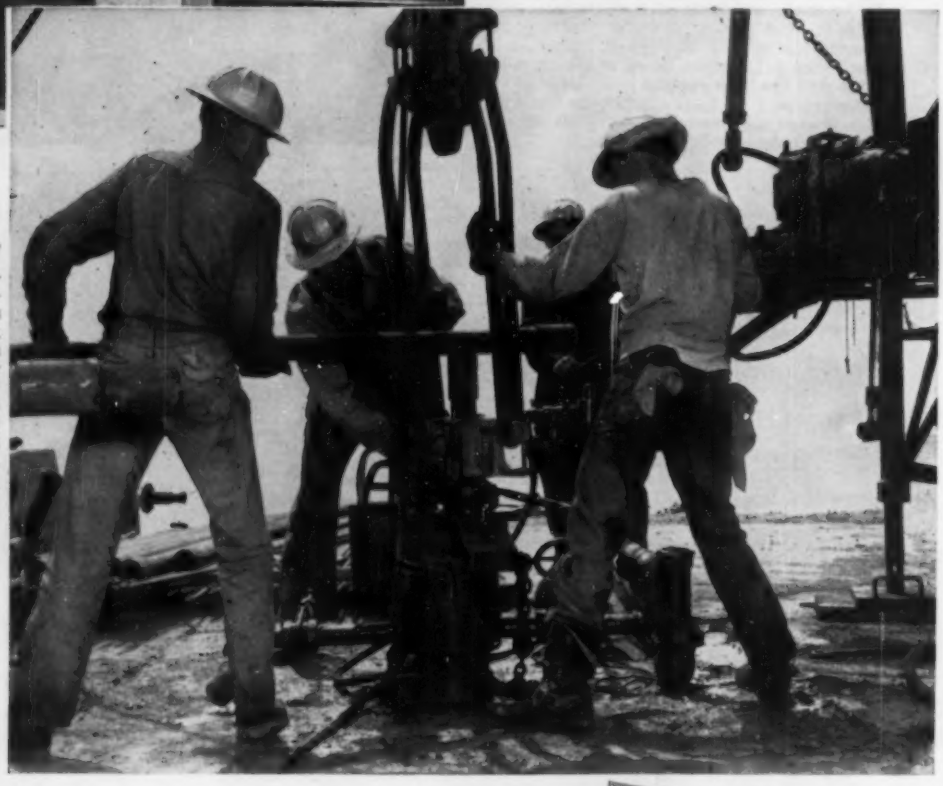


HARD WORKER. Operating at 6 strokes per minute, this Axelson Long Stroke Hydraulic Pumping Unit pumps from a 9,300 ft. depth in the Sarrah Burks Lease near Lindsay, Oklahoma for Magnolia Petroleum Company. These units are recommended where large volumes must be raised from great depths. The slow pumping rates increase the life of sucker rods and sub-surface pumps as high as 8 times their normal life expectancy. A 2½ x 1¼ x 40 Axelson Rod Liner Pump is at bottom. W. T. Holman is the Pumper.

SMALL WONDER. This is one of 18 Axelson Hydrax pumping units specially designed for Union Oil Company to pump the low gravity crude (8.5 to 13) in the Guadalupe Field, California. A diluent is pumped down Axelson Hol-O-Rods and an Axelson TLE pump with Duax Liners lifts 65 B/D with 50% sand cut from 3,100 ft. (l to r) Bob Talley, District Foreman; Cliff Dunham, Assistant Production Foreman; Bob Smith, Production Foreman (all of Union Oil Company). Chuck Garner and Bob Quinn (Axelson).

AXELSON PICTORIAL

PUBLIC DEMONSTRATION. Harold F. Allen, Science Instructor at Coalinga College, California, uses a model of an Axelson RLA (rod-type) subsurface pump to explain the principle of artificial lift to his engineering students. Axelson gladly makes available these model oilwell pumps to schools and colleges for classroom study. A 15-minute demonstration will often save hours of classroom discussion and blackboard diagramming.



TUBING RUN. High on a hill overlooking the blue Pacific at Capitan, California, General Petroleum Corp's well service crew runs tubing back into the well while Hydro-Test runs a simultaneous check for tubing leaks. Equipped with an Axelson 2" RLB Pump and Axelson ¾" #59 Sucker Rods, this well makes 12 B/D of 28 gravity crude from 2,600 ft. (l. to r.) Edwin Bruce, June Garland, Burl Hankey (Gang Pusher), Cecil Sutton.

AXELSON

AXELSON MANUFACTURING COMPANY

Division of U. S. Industries, Inc.

6160 South Boyle Avenue, Los Angeles 58, California

Specify **AXELSON** *for*
Subsurface Pumps
Sucker Rods
Hydraulic Pumping Units
Stuffing Boxes & Packing
for better production

Where to buy Axelson Production Equipment:

CALIFORNIA: *Axelson stores at Bakersfield, Coalinga, Huntington Beach, Long Beach, Orcutt, Santa Fe Springs, Taft, Ventura; Hickey Pipe & Supply Co. (Sucker Rods)* • **MID-CONTINENT:** *Jones & Laughlin Steel Corporation, Supply Division (Headquarters, Tulsa)* **ROCKY MOUNTAINS:** *Jones & Laughlin Steel Corporation, Supply Division; Great Northern Tool & Supply Co., Billings, Montana* • **CANADA:** *Jones & Laughlin Steel Sales Co. Ltd., Calgary; Dominion Oilfield Supply Co. Ltd., Calgary* • **MEXICO, D. F.:** *Wells Fargo & Co. Express, S. A.* • **RIO DE JANEIRO, BRAZIL:** *MAQUIP (Commercial de Maquinas e Equipamentos) S. A.* • **LIMA PERU:** *Gross Equipment, S. A.* • **LA PAZ, BOLIVIA:** *Del Prado & Compania, Ltd.* • **BUENOS AIRES, ARGENTINA:** *Adrian Bolland & Cia., S. R. L.* • **BARCELONA, VENEZUELA:** *Servicios Industriales, C. A.* • **MARACAIBO, VENEZUELA:** *Servicios Industriales, C. A.* • **BOGATA, COLOMBIA:** *Servicios Industriales, C. A.* • **TRINIDAD, B. W. I.:** *Industrial Agencies, Ltd.*

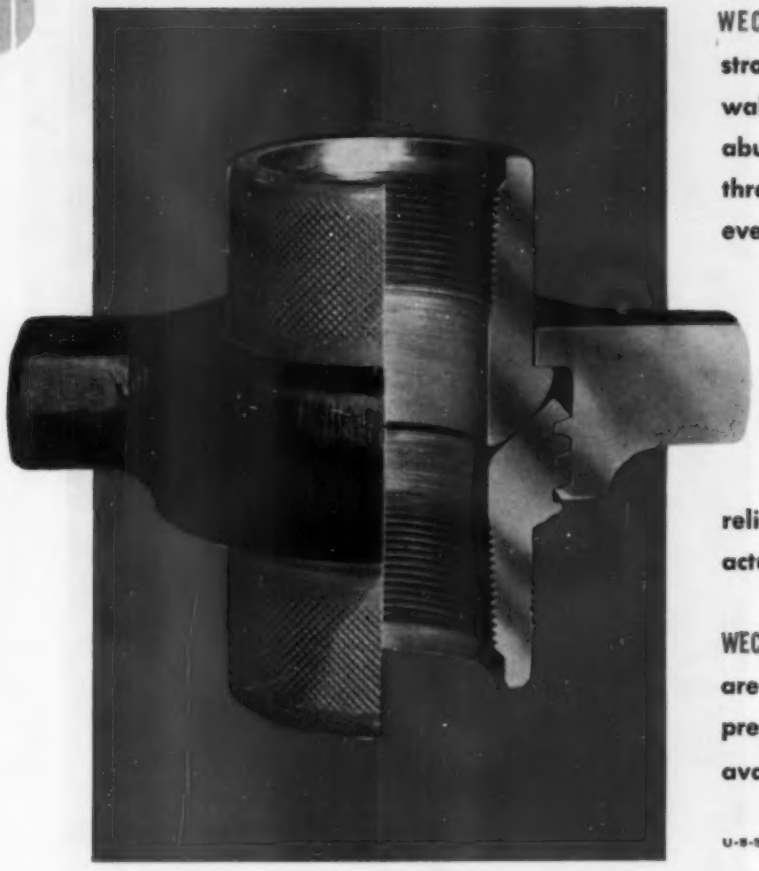
Where to buy Axelson Hydraulic Pumping Units:

CALIFORNIA: *Axelson stores (see above)* • **ODESSA:** *Axelson Warehouse* • *Industrial Supply Company stores at* **DALLAS, ELECTRA, FORT WORTH, FREER, HOUSTON, KAMAY, MIDLAND, ODESSA, SAN ANTONIO, SNYDER, TULSA, TURNERTOWN, WICHITA FALLS** • *Mountain Iron & Supply Company stores and offices at* **ANTHONY, AUGUSTA, BARTLESVILLE, DENVER, GREAT BEND, INDEPENDENCE, KIMBALL, LEROY, MADISON, McPHERSON, PARKERSBURG, PLAINSVILLE, RUSSELL, TULSA, WICHITA** • *Export (See above).*

the three R's

OF SUPERIOR UNION SERVICE

RUGGED
RELIABLE • RIGHT



WECO UNIONS ARE BUILT RUGGED with stronger subs and wing nuts, heavier wall construction to take rough use-and-abuse in the field. Their rugged Acme threads make-up fast and accurately—even after repeated break-out.

WECO UNIONS ARE RELIABLE. Their famous metal-to-metal ball and cone seat gives positive protection against leaks from shock, surge and vibration. Because they provide such reliability, Weco Unions last longer—actually cost less in the long run.

WECO UNIONS ARE RIGHT wherever unions are required. And there's a size and pressure for every requirement. They're available from supply stores everywhere.

U-8-56

WECO®

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS

Division of CHIKSAN COMPANY *a subsidiary of*
FOOD MACHINERY AND CHEMICAL CORPORATION

NEW Bucyrus-Erie 85-Ft. SERVICING DERRICK Simplifies Deep Workovers with 48-L

Here's an important addition to the long list of significant Bucyrus-Erie research developments in spudder design — an 85-ft. servicing derrick as special equipment for the 48-L spudder. Based on careful study of field needs, the new derrick provides added height without sacrifice of portability for fast, profitable clean-out, rod and tubing, or other servicing work. Its welded steel structure is similar to the 48-L's standard 60-ft. derrick which is unexcelled for strength and durability. Check the new derrick's outstanding features:

AMPLE HEIGHT

- Plenty of lifting space to pull 30-ft. doubles.

BIG CAPACITY

Handles up to 60,000 pounds of tubing.

STRONG STRUCTURAL DESIGN

12-in. lower section channels, 11-in. upper section channels. Upper section is made of laced angle construction.

SIMPLE DESIGN

Telescoping 2-section derrick is power lowered, lays down over spudder for fast road travel.

CONVENIENT TUBING RACK

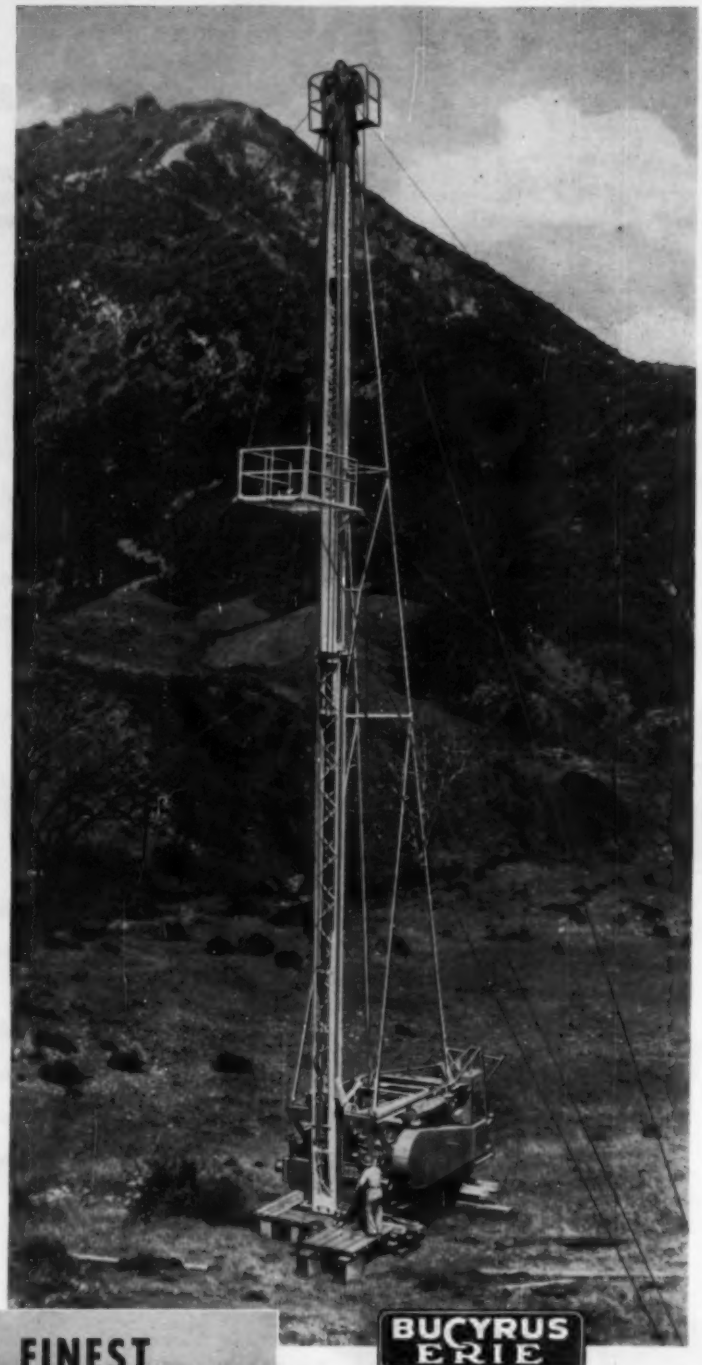
A fingerboard for racking well tubing is arranged to hold a total of 7,920 feet in 60-ft. stands.

EASY FIELD ERECTION

Power-raised with built-in oversize derrick hoist drum using 4-part hoisting line. When fully extended, guy lines can be set quickly — four each from the lower section, the fingerboard, and the top of derrick respectively.

This new-type derrick is available for 48-L s already in the field, or it may be ordered with a new machine in place of the standard derrick. Write today for complete details.

34556



FIRST with the FINEST in Spudders

BUCYRUS ERIE

SOUTH MILWAUKEE, WISCONSIN

the "bit line" to your rig...

Every working day, big transport trucks like these load rock bits at our plant warehouse for delivery to more than 150 Hughes field stockpoints throughout the United States and Canada. The final destination — your rig!

In maintaining these ample stocks, Hughes Tool Company's high capacity production lines operate 'round the clock, 'round the year. As a result, the bits available for delivery to your rig are always *right* as to size, type and design for your drilling requirements.

More "Flash-Weld" joints from Hughes are going overseas

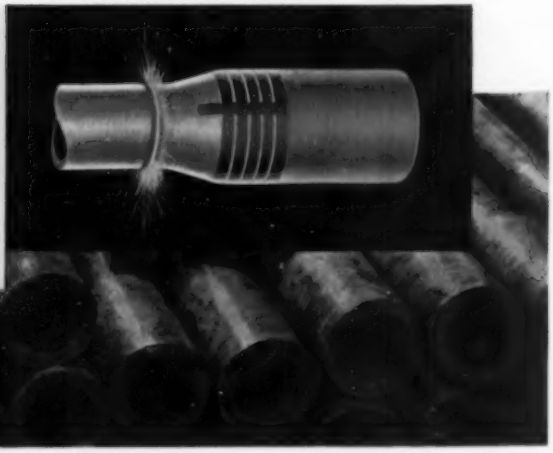
The proved *economy* and *dependability* of Hughes "FLASH-WELD" tool joints is resulting in their increased use overseas. And here is why:

1) Hughes' hardfaced "FLASH-WELD" joints last the life of the drill stem — *don't have to be replaced*. And they may be safely rehardfaced in the field.

2) Hughes' "FLASH-WELD" joints eliminate the burden of replacement inventory, also the duty and cost of transporting and handling extra joints.

3) The highly specialized machines and processes pioneered and developed by Hughes exclusively for flashwelding tool joints to pipe assure a superior, more dependable drill stem.

FLASH-WELD
A DEVELOPMENT
OF
HUGHES
TOOL COMPANY
HOUSTON, TEXAS



Still on the job after 9 years with

MARVEL INVERSE OILER—

Vital Part of World's Finest Engines

The Marvel Inverse Oiler ⟶

is an integral part of the Waukesha NKRU gas unit. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

STILL ON THE JOB after *nine years'* service! This dependable Waukesha NK Series engine, pictured above, has *never* had the head or pan off in all this time.

Like most fine performers, the Waukesha engine is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant on the market.

For engine manufacturers have found that engines equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down time" low by extending periods between overhauls.

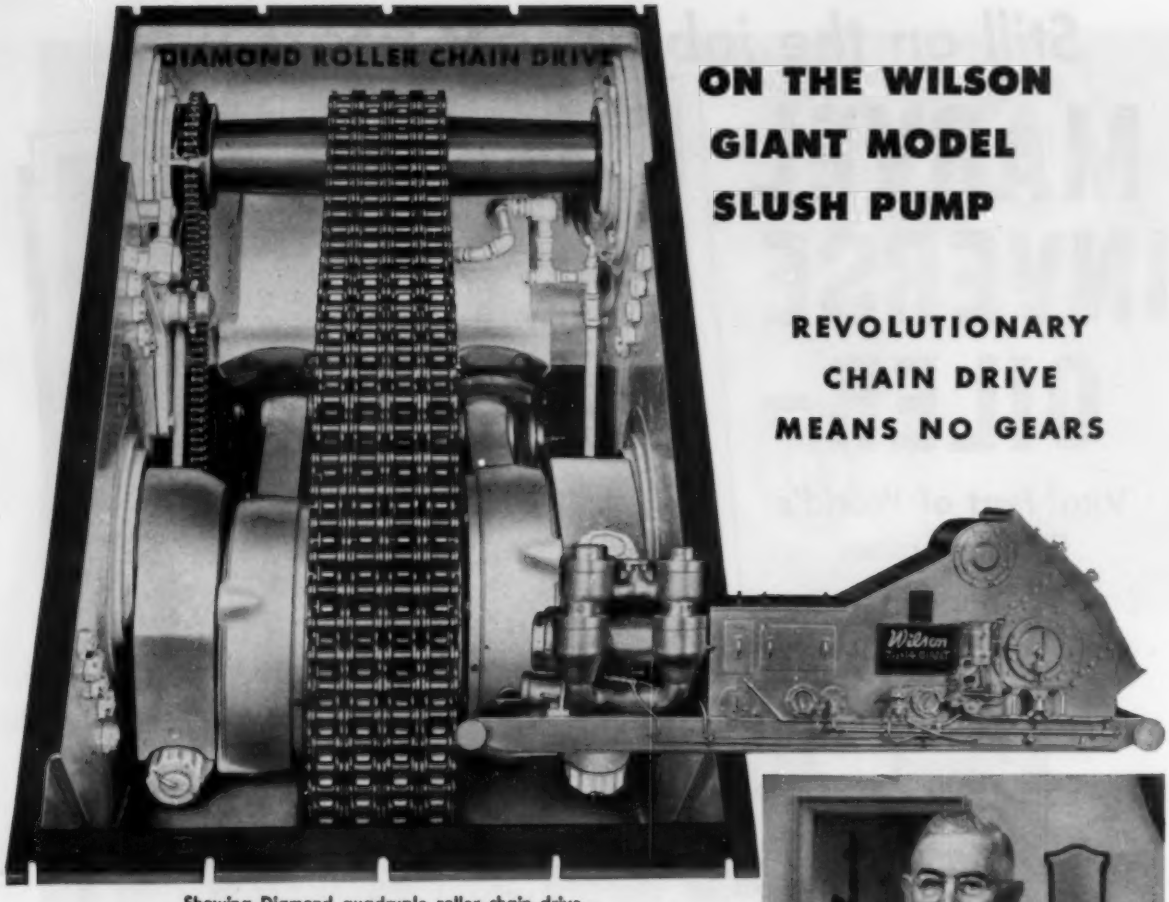
The Marvel Inverse Oiler, incorporated as a vital unit in the engine's lubrication system, feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. It keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages.

Of course, it is actually the oil that performs these functions and only Marvel Mystery Oil is blended for this purpose and for the Marvel Inverse Oiler!

See Your Local Jobber or Oil Well Supply House

EMEROL MFG. CO., Inc.

Dept. 433, 4242 West 69th Street New York 23, N. Y.



Showing Diamond quadruple roller chain drive on Wilson Giant Model Slush Pump.

ON THE WILSON GIANT MODEL SLUSH PUMP

REVOLUTIONARY CHAIN DRIVE MEANS NO GEARS

MORE EFFICIENT-OPERATION WITH DIAMOND ROLLER CHAIN DRIVES

For this new slush pump, Wilson Manufacturing Co., Inc. have replaced gear drives with quadruple Diamond Roller Chains. This has added to the efficiency, has reduced weight and has eliminated damage often caused by gear tooth breakage. Smooth, non-slipping, long-life operation is assured in the handling of high volumes, pressures and capacities.

This is another example of successful Diamond Roller Chain application, good evidence of their continued preference ever since the early days of mechanized oil country machinery.

Mr. John H. Wilson, President and Chief Engineer, Wilson Manufacturing Co., Inc. A pioneer in the design and manufacture of modern oil field machinery.

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

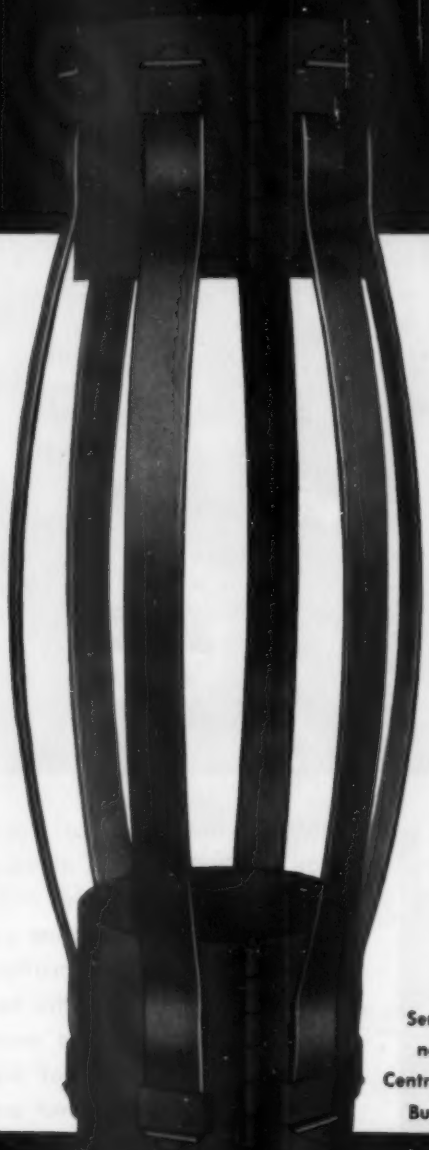
Dept. 441, 402 Kentucky Avenue, Indianapolis 7, Indiana
Tulsa Office: 2238 Terwilleger Blvd.

Offices and Distributors in All Principal Cities

Please refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER

DIAMOND ROLLER CHAINS

announcing.. BJ RED TOP CENTRALIZERS



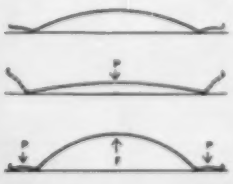
the first really NEW centralizer in years...

Now, Byron Jackson brings you the most advanced centralizer on the market. The exclusive new pre-stressed spring design gives Red Top Centralizers maximum centering force without resorting to heavy "high-bow" springs. Centering force without bulky springs gives better mud and cement circulation. Specify Red Top Centralizers on your next casing job – and your crew will give you a faster, better cement job.

NEW	pre-stressed springs give maximum centering force
NEW	ease of mud or cement circulation... no heavy or "high-bow" springs to obstruct flow
NEW	smaller diameter allows easy passage through spider and rotary table – eliminates banding and cutting
NEW	rivetless, weldless construction...no uneven stress pattern or brittleness

Send for new BJ Centralizer Bulletin

HERE'S HOW BJ's EXCLUSIVE PRE-STRESSING WORKS:



1. Spring used in a Red Top Centralizer at rest.
2. If pressure (P) is applied the ends of the spring will rise.
3. Conversely, if pressure (P) is applied to the ends, the spring is "pre-stressed" and exerts force (F) outward.

EXPORT ADDRESS: 580 Fifth Ave., Suite 510, New York 36, N.Y.

Sales Engineers in all principal oil fields

BYRON JACKSON TOOLS

INCORPORATED

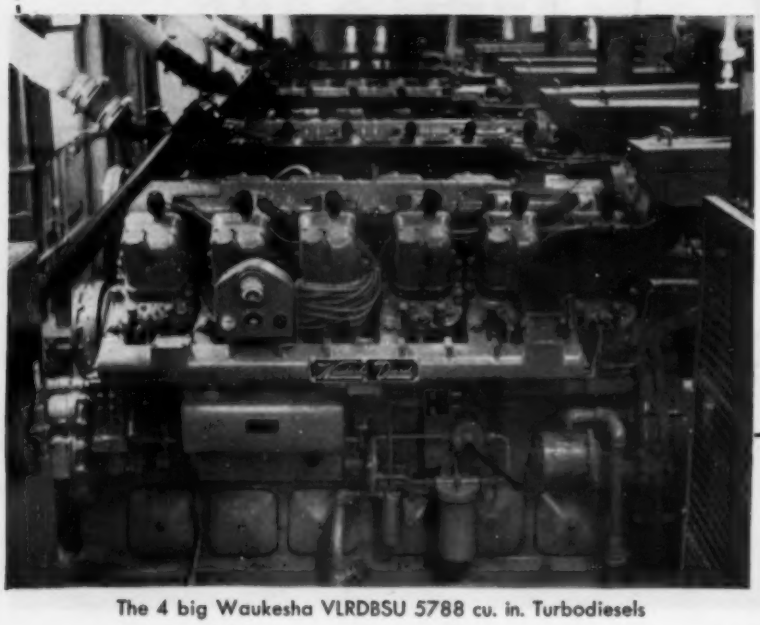
A SUBSIDIARY OF BORG-WARNER CORPORATION

P.O. Box 2017A, Terminal Annex, Los Angeles 54, Calif.

Offices in Houston, Fort Worth, Denver and New York

4 Big WAUKESHA V-12 *Turbodiesels*

Power this NEW OFFSHORE DRILL RIG



The 4 big Waukesha VLRDBSU 5788 cu. in. Turbodiesels

● This elevated deck offshore barge was built for the California Co. by Avondale Shipyard; drilling equipment and operation by the Noble Drilling Corporation. Oil men who have seen this remarkable equipment were much impressed by the array of big Waukesha Turbodiesels which are the prime source of power.

WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN
New York • Tulsa • Los Angeles
319

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Safety INSURES Service

Welex service means equipment designed for safety and efficiency as well as safety-conscious crews at work on your location to guarantee you

- *Better job performance*
- *Investment Security*
- *Personnel Protection*
- *Minimum rig time*
- *Results you can rely on*

Perforating *AND SAFETY* are no sidelines with Welex

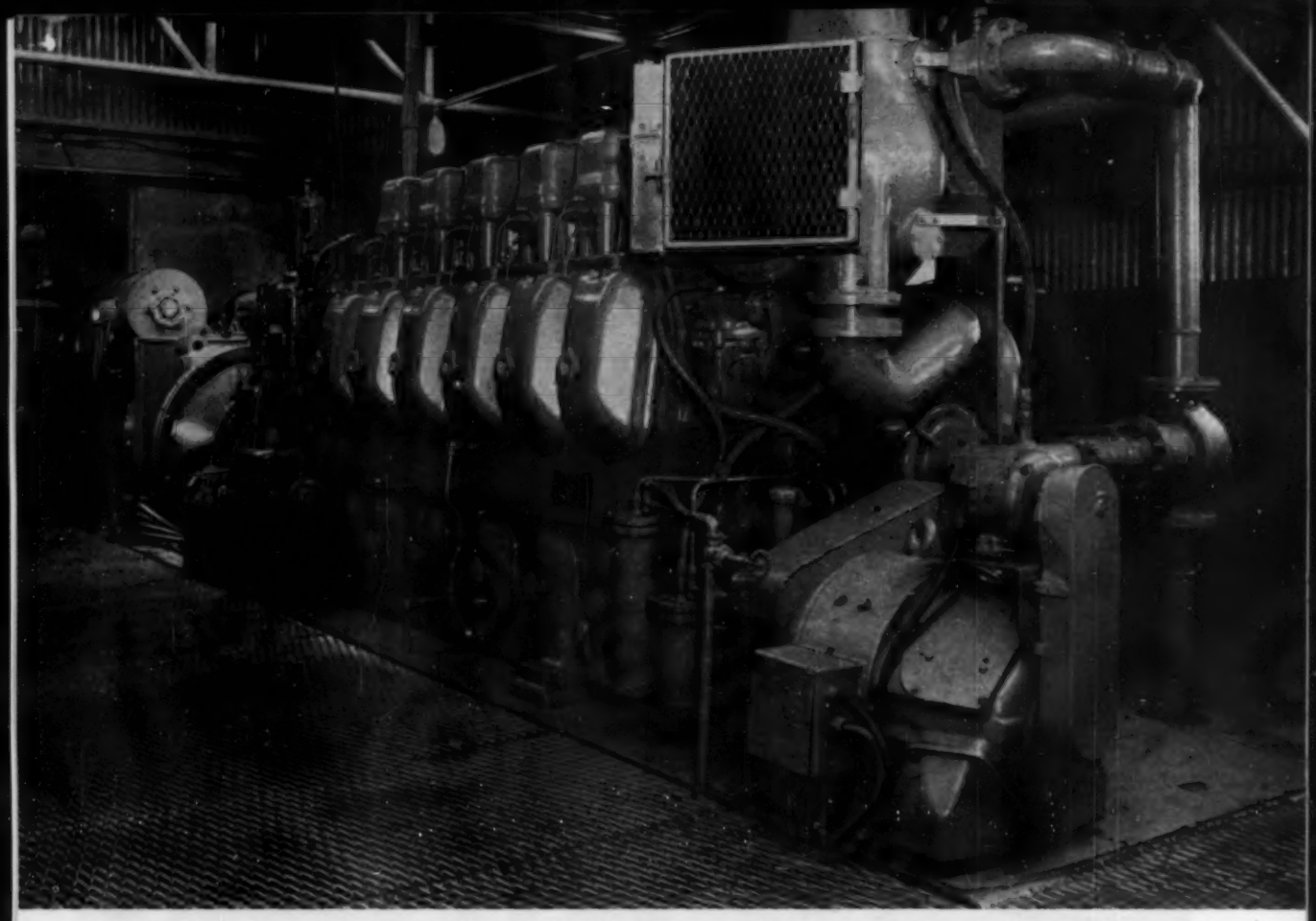
ORIGINATORS OF Welex JET PERFORATING

Welex JET SERVICES, INC.

General Offices: *1400 E. Berry St., Fort Worth, Texas*

SALES OFFICES: *Dallas, Wichita*
DIVISION OFFICES: *Houston, Midland, Tulsa, Oklahoma City, Denver*
DISTRICT OFFICES: *Abilene, Ardmore, Beaumont, Corpus Christi, Falfurrias, Farmington, Fort Morgan, Great Bend, Hobbs, Houma, Houston, Kimball, Lafayette, Lake Charles, Liberal, Odessa, Pampa, Pauls Valley, Pawhuska, Plainville, San Angelo, Shawnee, Sherman, Snyder, Stillwater, Wichita Falls, Winfield*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



ALCO 251-B DIESEL ENGINE *in service on Shoreline Drilling Company oil-well drilling barge. Barge recently completed its second hole, which went 15,000 ft deep. First* ALCO *plant, owned by Bateman Drilling Co., has drilled over 80,000 ft. Offshore Company's first* ALCO*-powered rig has completed two holes. Drillers report excellent performance of* ALCO *equipment.*

NEW ALCO DRILLING PLANT GIVES COMPLETE POWER, SMOOTH CONTROL, FLEXIBILITY

Plant Provides All Power For Drilling; Includes Split-Second, Reliable Control; Skid-Mounted Units Solve Weight Distribution and Add Flexibility.

The ALCO drilling plant provides all the advantages of diesel-electric power: smooth, pin-point control, steady acceleration without load shock to engines and other equipment, power that's instantly available. It means that you can spend more time drilling, less time in mechanical control changes and equipment maintenance. It even means that you spend less time changing bits, or pulling your string out of the hole for any reason. In addition, the ALCO plant can drill as long as one engine is running—it does not depend on auxiliary generators or engines.

All components are skid-mounted. You distribute weight on a barge as required, save setup time on land installations. Components can be trucked from location to location.

Two engines in the ALCO plant provide 1370 hp for draw-works drive and 600 hp for each of two mud-pump drives, plus power for lighting and other auxiliaries. A wide variety of modifications is available, such as larger mud-pump, rotary and coring reel drives.

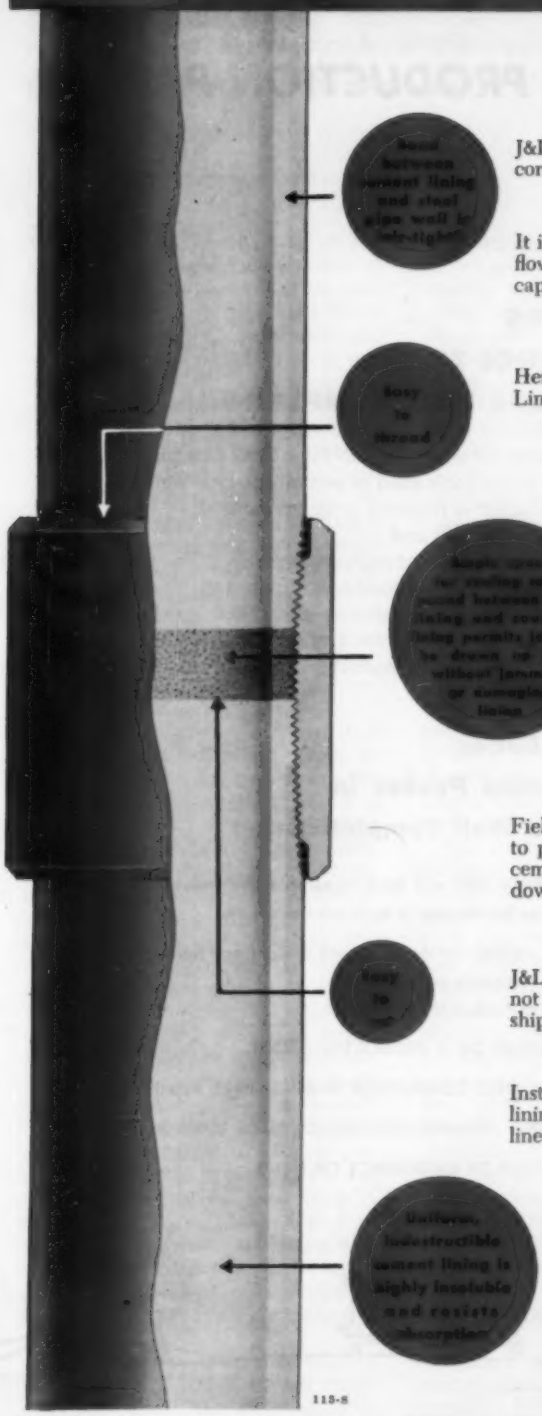
The ALCO plant's cost is comparable to that of an ordinary plant. It is built and backed by the pioneer of locomotives and diesel-electric power. Contact your nearest ALCO representative or write P. O. Box 1065, Schenectady 1, N. Y. for details.

ALCO

ALCO PRODUCTS, INC.
NEW YORK
Sales Offices in Principal Cities

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment

J&L CEMENT LINED CASING, TUBING, LINE PIPE


Bond between cement lining and steel pipe wall is absolute
Easy to thread
Simple screw-in sealing compound between pipe lining and coupling lining permits joint to be drawn up tight without jarring or damaging lining
Easy to cut
Uniform, indestructible cement lining is highly insoluble and resists absorption
118-8

USES-ADVANTAGES

J&L Cement Lined Steel pipe is designed specifically for handling corrosive liquids.

It is satin smooth, resulting in a lower friction coefficient and higher flow efficiency than for unlined pipe. Therefore, the carrying capacity is greater than steel pipe of the same I.D.

Here are a few of the many applications in which J&L Cement Lined Steel pipe offers outstanding advantages:

1. Lines in salt works for handling brine.
2. Lines in process plants where water or other liquids must be kept free from iron contamination or rust.
3. Oil field flow lines, pipe lines, tubing and casing, where salt water, hydrogen sulfide, carbon dioxide and other corrosive materials are present.
4. Lines in paper and pulp mills for handling diluted acids and corrosive waste liquids.
5. Discharge lines in coal mines for carrying highly corrosive sulphur water.
6. Hot water lines where ordinary pipe is subject to tuberculation.
7. Municipal water works systems.

Field joints are made up with a putty-like sealing compound, easy to prepare and use. It affords protection at this point equal to the cement lining in the pipe. Field joints can be made up and broken down as often as necessary without damage to the cement lining.

J&L Cement Lined Pipe will withstand any exterior blow that does not dent or deform the steel. It requires only normal handling in shipping and unloading.

Installation requires no special knowledge or skill. The pipe and lining can be cut with a metal saw, or a power bandsaw. Cement-lined tees, ells, crosses, unions, and other fittings can be supplied.

Jones & Laughlin
SUPPLY DIVISION – Tulsa
SERVING THE UNITED STATES AND CANADA

For Permanent-Type Well Completions

THE BAKER

RETAINER PRODUCTION PACKER

PRODUCT NO. 415D

BAKER PACKERS ADD PERMANENCE TO PERMANENT-TYPE WELL COMPLETIONS

When you select a Packer for a Permanent-Type Well Completion, remember this fact: of all the tools used in permanent-type well completions, only the *Packer* is required to be *permanent*. Guns, Extensions, Plugs, Gas-Lift and Circulating Valves can be removed or replaced on wire line . . . but the Packer, like the casing, is required to perform for the life of the selected producing intervals. Baker Packer Completions are Permanent Completions from the standpoint of packer performance.

Advantages of Baker Retainer Production Packer in Permanent-Type Well Completions:

PERMANENT, RELIABLE PACK-OFF will hold against any pressure differential from above or below that is safe for the casing.

FREE TUBING STRING . . . neither set-down tubing weight nor tubing tension required to achieve and maintain pack-off. Tubing can be anchored to Packer if desired.

CAN BE USED AS A SQUEEZE OR A PRODUCTION TOOL.

MEETS PERMANENT-TYPE WELL COMPLETION DIMENSIONAL REQUIREMENTS.

CAN BE SET ON WIRE LINE. PERMITS EASY REMOVAL OF TUBING STRING.

READILY DRILLABLE IN CASE OF EMERGENCY OR NEED.

BAKER OIL TOOLS, INC. HOUSTON • LOS ANGELES • NEW YORK

Horizons Unlimited In Well Workovers

Some 50,000 workovers were performed last year . . . most of them to increase productivity. Much of our nation's recoverable reserves can be attributed to well work. Techniques have come a long way...and the horizon is unlimited.

Don Taylor, *Gulf Coast Editor — Houston*

THE care and maintenance of this nation's producing wells has become of paramount importance and is big business. With new reserves more difficult to discover, and the cost of each new barrel of oil found on the upswing, well workovers become a highly significant phase of oil and gas field operations. To be of value to anyone, petroleum reserves tapped by the bit must be brought to the surface. It is the function of well workovers to keep our wells producing at their most efficient rate commensurate with the economies involved. The job may involve mechanical repairs to the well, or more technique to increase the well's ability to produce. In any event, the objectives are similar . . . recover all the oil and gas possible in the most efficient and economical manner.

Thanks to great technological advances made in recent years by engineers and service companies, the success factor of well workovers is continually rising, while the average cost of these jobs is advancing but little. There are new developments in our laboratories today that will further increase this success ratio and further reduce the cost of well workovers. This is quite significant in view of the upswing in number of wells being worked over each year. It is estimated that about 10 per cent, or approximately 50,000 wells are worked over each year in the U.S. This is not an unreasonable figure, and when put on a one-well basis, it appears more reasonable than ever. This would mean that one producing well would require some form of well work every ten years. Actually, this may not be frequent enough even for the average well. But, suffice it to state that any well completed as a producer will, at some time during its producing life, require some manner of well work.

The importance of workovers cannot be overstressed. Today, we are recovering only about half the total petroleum deposits discovered. In many dissolved-gas drive reservoirs, (which incidentally are noted for their inefficient drive) the recovery may be less than 30 per cent of oil in place. With consumption of petroleum steadily increasing, it is of primary concern to get out of the ground efficiently and economically all the oil and gas possible. Pressure maintenance and secondary recovery will play the star role in this effort, although well stimulation and other well work have and will continue to add much to our recoverable reserves.

But, even so, we are abandoning millions of barrels of oil in the ground because production from problem formations fail to maintain a commercial (or economic) rate of flow. More successful workover techniques would prevent many of these abandonments. It would save a number of oil fields that are abandoned after the initial discovery well fails to produce commercially.

One case in point is that of a discovery of the deep Wilcox on the Texas Gulf Coast. An operator set pipe below 10,000 ft to attempt a completion in an 18-ft sand. Cores, logs and drill-stem tests made during drilling indicated a commercial reserve of high gravity oil and gas. The well was completed as a discovery and flowed for two or three months, then turned to salt water. Efforts to shut off the water, which probably came from a lower formation, proved futile, and the operator wisely abandoned the well . . . and a new oil field was scratched. And, yet, the oil and gas were there, perhaps in considerable quantities. Missing was the skill, techniques and devices by which to positively isolate the producing zone. Present-day techniques probably would have turned this discovery into a booming oil field.

When a bit penetrates an oil and gas bearing zone, at best, the formation is damaged from its virgin state . . . and, it is this damage that will determine how well, or if at all, the well produces. Best completion practices are designed to minimize this contamination or damage. The degree of contamination may be slight in some cases, but in problem formations, this damage can be almost irrepairable. In fact, the drill bit has been responsible for migration of oil or salt water from one formation to another. It has unleashed drives equal in force to water flooding. Where contamination or damage has been incurred to the producing formation, well workovers have made it possible to repair some of this damage, and in some instances improved the producing characteristics above its virgin state.

The critical steel situation and the limited supply of casing has focused attention to workovers of existing wells. Objective here is not only to utilize to the fullest equipment and men in the field, but to increase oil output to make up for oil not produced from wells undrilled because of a lack of casing. One company increased its oil production in 1955 some 460,000 bbl accredited solely to working over 262 wells.

Workovers of the future. One of the most promising developments has been in the field of permanent completions which permit all manner of well work by means of wire line methods. Techniques and equipment are being improved at a rapid rate thereby expanding application of this completion idea. Workovers will be cheaper, safer and quicker, thereby encouraging the operator to take action when a problem well is involved. Savings attributed to wire line workovers in permanently-completed wells now probably amount into the millions. Techniques are in the test stage for working over offshore wells through the flow line, thereby enabling a number of wells in a marine field to be worked over from a centrally-located platform. Unitized services, standardized equipment, and continued interest and development indicate that permanent type completions bear close attention.

Drastic improvements and new techniques and materials have come into the field of well stimulation. Knowledge of what takes place below ground has been expanded appreciably. Mechanical repairs are not as uncertain and improbable as they used to be. But, with all the improvements and developments in the recent past, those ideas now being tested, and others in the research laboratories, the field is still wide open, and there remains much work to be done to further improve methods for working over producing wells to the end that maximum efficient recovery is obtained at a minimum expense. The horizon is truly unlimited. * * *

The Men Behind This Special Workover Issue

14 specialists combine their engineering talents and experiences to give you the industry's first workover handbook

Across these two pages are the men responsible for the top-notch, practical engineering information contained in this special issue on a vital subject. It is with considerable pride that *The Petroleum Engineer* presents this outstanding group to its readers. They have contributed exclusive material to make this issue an editorial achievement which will be difficult to duplicate for some time to come. We are indeed indebted to these men for their time and effort to put on paper their latest thinking and experiences on the various phases of well work. In effect, this single issue is actually a reference piece put together by one of the most impressive groups ever to be presented in a single issue. Actually, they have served as a consulting engineering group for the benefit of the industry at large.

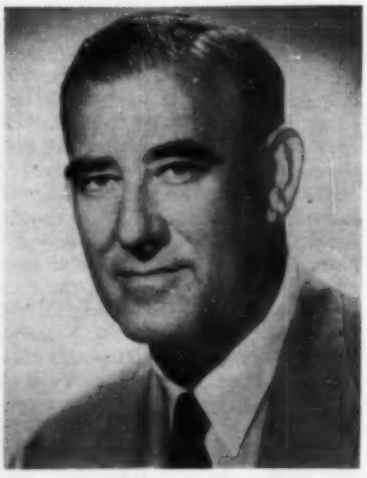
It is doubtful that you will find any one issue of this publication or any other so filled with exclusive information on a single subject by such an array of engineering talent. The entire *Petroleum Engineer* organization extends our warmest thanks to these men for their participation, and after you have reviewed what they have written, we feel you will also thank them.

Raoul Bethancourt
Staff Petroleum Engineer
Sun Oil Company
Dallas, Texas

Norman J. Clark
Assistant Manager
Engineering and Consulting Department
Core Laboratories, Inc., Dallas, Texas

M. J. Kaufman
Area Supervising Petroleum Engineer
Phillips Petroleum Company
Bartlesville, Oklahoma

Royal W. Reiss
Chief Engineer and General Superintendent
Oil and Gas Department
Mining Division, ALCOA, Houston, Texas



John J. Arps
Vice President
British-American Oil Producing Co.
Dallas, Texas

Cliff J. Rodgers
Division Staff Engineer
Gulf Oil Corporation
Houston, Texas

Gilbert H. Tausch
Petroleum Engineer
Humble Oil & Refining Co.
Houston, Texas

T. C. Aitken
Petroleum Engineer
Sun Oil Company
Gainesville, Texas

S. S. Galpin
Assistant Superintendent, Oakford District
New York Natural Gas Co.
Jeanette, Pennsylvania

Don A. Klemme
Safety Supervisor
Stanolind Oil and Gas Co.
Tulsa, Oklahoma

J. N. Pedersen
District Petroleum Engineer
The California Company
Natchez, Mississippi

W. P. Schultz
Senior Engineer
Engineering and Consulting Department
Core Laboratories, Inc., Dallas, Texas

Price McDonald
Petroleum Engineer
Humble Oil & Refining Co.
Houston, Texas

Palmer H. Montgomery
Storage Engineer
United Natural Gas Co.
Oil City, Pennsylvania

SPECIAL Well Workover FEATURE

An Approach to Analyzing Ailing Wells

A systematic approach to an oft times difficult and yet significant phase of production. The outcome depends upon the accuracy of analysis.

Raoul Bethancourt
Sun Oil Company, Dallas, Texas

One of the most important and often difficult phases of wellwork is that of determining if remedial work is necessary. In a number of instances the need will be obvious but the method of repair may be subject to doubt and argument. This situation can be compared very readily to that of a doctor and his patient. He must first obtain a broad knowledge of the illnesses and ailments that he may be called upon to cope with. Then, he must have detailed information of the characteristics and ways of identifying the ailment. The young doctor may refer many times to his medical encyclopedia for this tabulated information. The more widely experienced physician may only consult his books on rare occasions, and then to check some detail that is unusual. If he is in doubt, he may discuss the patient with his colleagues.

One good approach to the problem of determining workover possibilities for those who do not have broad experience in this field would be to list a majority of the procedures that are commonly used and list those factors that would be pertinent to the particular type of wellwork. Wellwork is arbitrarily defined as any work which changes the producing characteristics of a well by any work done on, or to the formations present in the well bore. All other work can be defined as well service work.

Wells are divided into three general categories: (1) producing oil wells; (2) gas wells; and (3) project wells. Project wells are a special category that includes water injection wells, gas injection wells, water supply wells, disposal wells, hydrocarbon storage, etc.

Types of wellwork that more or less apply to all three categories of wells are:

A. **Workovers** are designated as all work on the present producing zone and includes such lesser categories as work to:
   1. **Shut off water.**
   2. **Shut off gas.**
   3. **Improve production** which, in turn, includes:
      a. **Reperforating**
      b. **Acidizing**
      c. **Fracturing** with various fluids, with or without sand.
      d. **Treating** with wetting agents to control bentonitic shale swelling or to remove water blocks or emulsions.
      e. **Removing** calcareous or paraffin deposits that obstruct well bore drainage
      f. **Deepening** in same sand.
      g. **Plugging back,** to shut off a trace of water to keep wells flowing.

B. **Repairs** are usually designated as that work necessary to the well or equipment to assure production or movement of fluid from the desired zone only.
   Primary jobs are:
   1. **Repair casing leaks.**
   2. **Repair cement job** behind pipe to stop communication to productive zone or separate two or more zones comingling behind the pipe.
   3. **Shut off sand** produced with well fluid.
   4. **Set liner** to prevent shale or sand sloughing into open hole.

C. **Recompletion** is where one or more producing zones are abandoned and a new producing zone in the well bore is brought in.

D. **Deepening** is the additional drilling to a new sand not present at the original depth.

E. **Conversion** includes a change in the category of a well i.e., usually from an oil well or gas well to a project well.

Workovers as a particular class of wellwork offer the best opportunity to predict the success of a proposed remedial program. Generally, more is known about conditions in the well bore and in adjacent wells in the field. If every precaution is taken to obtain all pertinent available facts, predictions as to the outcome of any of the work listed can usually be determined within a small per cent if the rating system of "Successful," "Partially Successful" or "Unsuccessful" is used and if sufficiently large number of wells are included to obtain a statistical average.

Shutting Off Water

A workover to shut off water requires that the source of produced water be accurately known. In the case of a well producing from one thin sand lense, the problem is relatively simple as water can only be coming from the producing sand lense or from a channel behind the pipe or from a leak in the casing. The first step then would be to positively identify the water and determine if it is normal formation water. In order to obtain this information, a water sample from the well must be compared with water obtained from nearby wells in which the formation producing the water has been established beyond reasonable doubt. This method is not always infallible.

In some cases, water from adjacent sections could be very similar and be very difficult to detect by laboratory analysis if one water source is comingled with another. Laboratory analysis relies to a great extent on the parts per million of sodium, calcium, magnesium, chlorides, sulphates and bi-

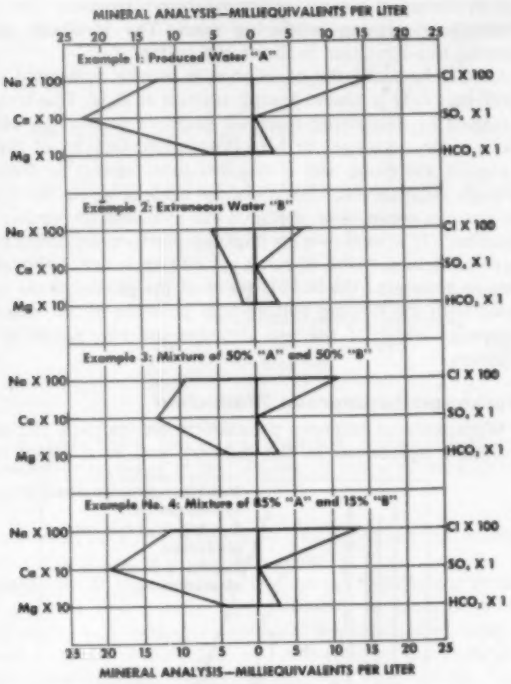

MINERAL ANALYSIS—MILLIEQUIVALENTS PER LITER
25 20 15 10 5 0 5 10 15 20 25
Example 1: Produced Water "A"
Na X 100
Ca X 10
Mg X 10
Cl X 100
SO4 X 1
HCO3 X 1
Example 2: Extraneous Water "B"
Example 3: Mixture of 50% "A" and 50% "B"
Example No. 4: Mixture of 85% "A" and 15% "B"
MINERAL ANALYSIS—MILLIEQUIVALENTS PER LITER

FIG. 1. **Mineral analysis** in the laboratory will, in most cases, identify and differentiate produced water. Here are some examples.

carbonates. If a simple comparison of the analysis is not sufficient, then pattern analysis can be used to make the comparison. (See Fig. 1)

If the water analysis does not provide a definite comparison, then temperature surveys may be able to indicate if fluid is flowing from one zone to another in sufficient volume to create a temperature anomaly; but this procedure may only be of assistance in a flowing well as temperature surveys on pumping or gas lift wells would be difficult and costly to run.

In multiple zones. Location of the water source becomes more complex where multiple zones are perforated in a well or where an open hole completion exposes two or more sand lenses. In either of these cases, the lense or perforations producing water must be located. One of the best ways to do this is to run two packers that permit testing below, between or above the packer to pinpoint the source of water. Care should be taken to produce the zone long enough to make certain that all of the load water has been removed and a true water test is obtained.

In any event, consult the geologist and reservoir engineer as they can be of considerable aid in calculating the oil-water contact. They may also be able to determine, in a case of multiple lense production, which of the stringers probably is producing water. They may be able to make a recommendation based on their intimate knowledge of the reservoir. Experience of other operators in the field is always helpful.

Squeezing and reperforating. In oil wells, if the producing formation is thick enough, it is possible sometimes to delay or minimize water production by squeezing and reperforating in the very top of the sand. Restricted rates of withdrawal aid materially in preventing water coning or fingering. In gas wells, it is almost always essential that a major shale break be present in the plug back job to separate the water from the gas zone. Attempts to shut off water in gas wells where only a very thin shale break (in the order of 3 ft) is present, are rarely successful. Theory is that if a successful job is actually performed to obtain a good cement job across the shale break, producing the gas section will result in a differential pressure across the thin shale break. The shale will rupture as soon as the area of the drawdown times the pressure differential equals the strength of the shale break.

Production history. Production history graphs are very important on work of this nature. Slow changes in water percentage tend to point to natural water encroachment. Sudden increases in water percentages usually point to the creation of a channel behind the pipe, the formation of a water cone, or a leak in the casing. These situations are discussed later.

After repairing the water flow, produce the well a sufficient length of time to unload water that may have flooded the producing oil or gas section.

Use of induction log. An induction log is now available that is very useful in determining water content of sands in open hole completions. This tool must be used before transferred water has an opportunity to water log the sand and thereby produce an erroneous reading.

Hot wire, dye and other methods of determining zones of water entry are not usually recommended because they must be used in flowing wells and are usually complicated and difficult to use and interpret.

Gas-Oil Ratio Repairs

Wells that produce with a high gas-oil ratio have two detrimental end results: (1) oil production is usually restricted by some formula to penalize high ratio wells; and (2) produced gas is wasteful of reservoir energy.

If studies indicate that a well is completed in the gas cap of a reservoir, nothing can be done to alleviate the situation that would conform to good production practice from a reservoir viewpoint. But, four other possible reasons for gas production exists. They are:

1. **An inverted gas cone** where too high a withdrawal rate has permitted gas to cone down through a lense with relatively

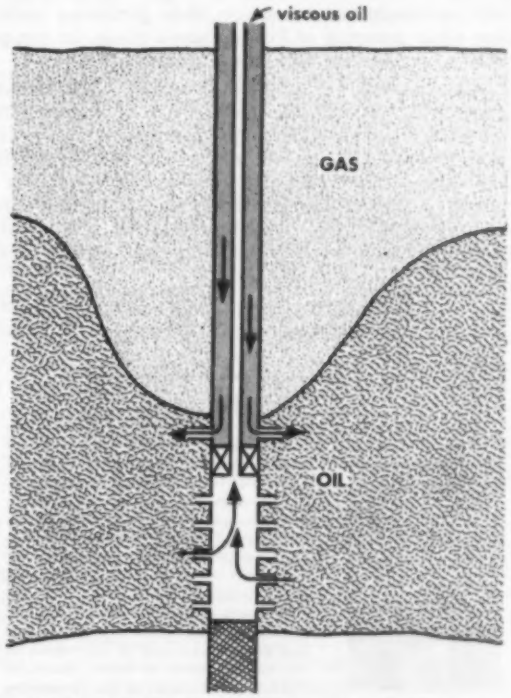


FIG. 2. **Gas-oil ratio repair** in an inverted gas cone by dumping in viscous oil in upper perforations above packer while producing oil beneath packer.

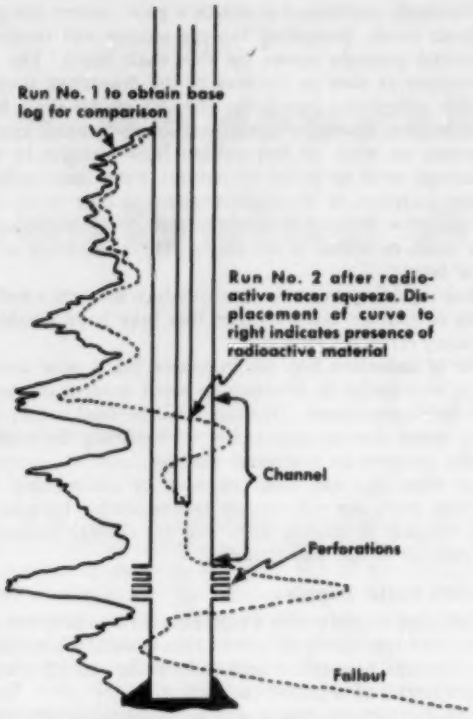

Run No. 1 to obtain base log for comparison
Run No. 2 after radioactive tracer squeeze. Displacement of curve to right indicates presence of radioactive material
Channel
Perforations
Fallout

FIG. 3. **Location of gas channels** by use of gamma ray logs run before and after a squeeze job with radioactive material.

high vertical permeability. Remedial work in this case has not been too successful. Instances have been known where the cone could be corrected to some extent by adding perforations as high as possible in the section, then producing under a packer while pumping in heavy viscous oil in the top perforation to prevent the cone from forming. (Fig. 2.)

2. **Gas channels** behind the pipe usually can be detected successfully by two methods. One way is to run a temperature survey while flowing at different producing rates. This method requires expert techniques and interpretations and even then, results may not be conclusive. The second method is by squeezing radioactive fluid into the formation and then checking the location of the radioactive material with a geiger counter. Fig. 3 shows detection of a gas channel by this method.

3. **In a multiple lense** reservoir or in a reservoir separated by impermeable streaks, source of the gas can be detected best by means of a sensitive temperature instrument run with gradually increasing producing rates. The idealized curve showing this condition is illustrated in Fig. 4.

4. **Gas breaking out** of solution is usually assoicated with a well that only produces a small amount of fluid. This trouble is caused by dissipating reservoir pressure to such an extent that gas can no longer be held in solution. Gravity of the oil is rapidly increased and it requires more energy to force it through the reservoir, thus a viscous cycle is set up until only the gas can move. Two methods are available to combat the situation: (1) a workover to improve production; or (2) pressure maintenance with injected gas and/or water. Laboratory tests to determine the bubble point of the produced oil compared with the flowing bottom-hole pressure of the well will determine which of the two remedies are best suited to the situation.

Workovers to Improve Production

Workovers to improve production are perhaps the most profitable operations in the industry and as a group have

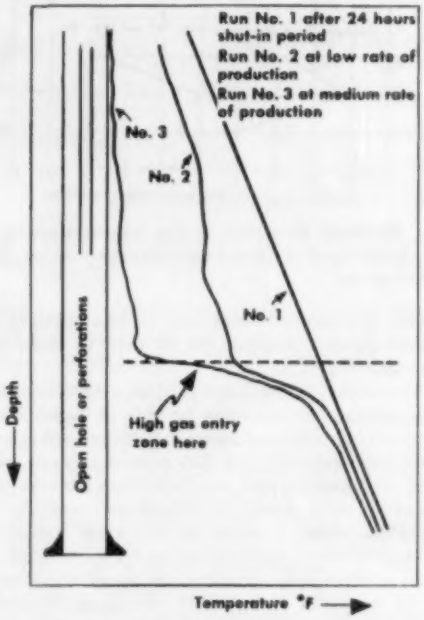

Run No. 1 after 24 hours shut-in period
Run No. 2 at low rate of production
Run No. 3 at medium rate of production
No. 3
No. 2
No. 1
Open hole or perforations
Depth
High gas entry zone here
Temperature °F

FIG. 4. **Temperature surveys** taken at different producing rates may indicate point at which gas is entering well bore, as shown above.

a much shorter payout than any other investment. This particular phase of wellwork is one in which the experience factor is most important along with an intimate knowledge of the reservoir and its mechanics. No effort should be spared to investigate results of work on offset wells and, if indicated, wells in the same field or even wells in other fields completed in the same formation.

All but one of the procedures in this category are concerned with the problem of improving or extending the drainage area around the well bore and increasing the producing bottom-hole pressure in the well. The other procedure to shut off a trace of water is an effort to make more effective use of the producing bhp by relieving the well of the burden of flowing through a stagnant column of water.

Best results from procedures to increase production will be obtained in wells that have indications of severe damage to the formation due to bad well completion practices or because of several factors that combine after completion to restrict flow into the well bore. Some of these factors are: formation of calcium carbonate scale or paraffin in the pro-

The Author

Raoul Bethancourt is a petroleum engineer in the Dallas Division of Sun Oil Company. He was born in southern Louisiana and studied electrical engineering at A & M College of Texas. He joined Texas Power & Light Company as a design engineer in 1935, and later was employed by Sun in Kilgore, Texas. He has been with Sun Oil Company since that time, except for 2½ years when the East Texas Salt Water Disposal Company was under organization. He has served in various engineering capacities with Sun in East and South Texas prior to his transfer to the division office in Dallas, Texas, in 1951. He is chairman of the Perforating Investigation Committee, a member of the API and AIME, served as local chairman of the API chapter in Corpus Christi, Texas, and is currently chairman of the Admissions Committee of AIME.

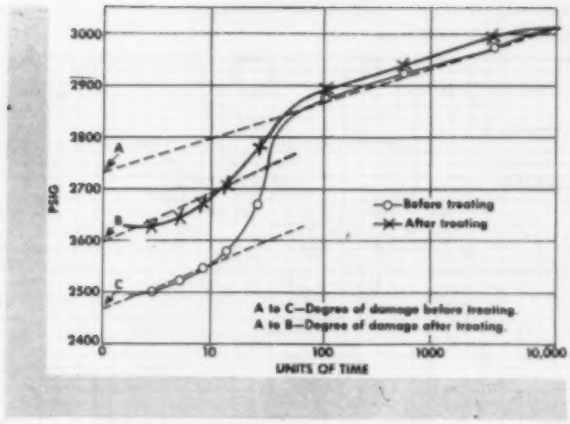


FIG. 5. **Idealized pressure buildup** curve to indicate permeability damage in the vicinity of the well bore. Note improvement after treating.

ducing zone, or a combination of water, oil, salt or swelling shale that will act as a plugging agent.

Diagnosis. If experience in the area is insufficient to act as a guide in determining the probability of a permeability block at the well bore, pressure build-up tests will determine if such a condition exists and will also indicate the degree of permeability damage. Numerous excellent articles have been published on this subject by well-known engineers. Reduced to simplest possible terms, the well bore damage is indicated by a change in the slope of the curve where the pressures are plotted on semilog paper against pressure and time, as illustrated in Fig. 5.

In many cases, where permeability damage is suspected, some operators prefer to treat the well in a manner that their experience dictates, rather than resort to the tedious and time-consuming pressure build-up curve method of analysis. Availability and cost of moving in rigs as compared to personnel and time necessary to run the pressure build-up tests are factors that contribute to these arbitrary decisions. One other item that influences this situation is the manner in which pressure build-up data are presented with long and complicated appearing formulas and strange symbols. Many practical production men either cannot or will not take time to find out how easy and simple the method really is.

When permeability damage around the well bore has either been proved or suspected, a decision as to the best approach to remedy the situation must be made. If experience is lacking, laboratory examination of available cores and analysis of the produced fluids will usually permit an experienced engineer to recommend one of the procedures or a combination of procedures listed to improve production.

Reperforating. Reperforating should be recommended where experience indicates that additional perforations have improved production under similar conditions. New perforating tools have increased penetration to a considerable extent and in some cases may be the answer to inadequate production. Perforating companies have also improved their ability to shoot in the desired section with the aid of supplementary logs and electric casing collar locators. Out-of-zone shooting with older methods in thin sands is always a possibility and should be considered when results of perforations do not come up to expectations.

Acidizing. Acid, available in many types and blends, should be used only if indicated by solubility tests on core samples of the formation to be treated. Service companies are always available to make these tests and determine which acid and additive to recommend. Avoid the use of acid additives unless their reactions in the formation are well known; additives used indiscriminately can be wasteful and under some conditions can be harmful. Avoid the use of acid where a poor cement job is suspected or where the gas/oil or oil/water contact is near the zone to be treated. Remember that acid will attack cement in preference to many formations and that it also has an affinity for water wet zones over oil wet zones. It can also move more readily through gas filled pore spaces than oil filled pores. As a consequence, acid seems to hunt gas or water. If in doubt as to the use of acid, consider reperforating or fracturing.

Another variation of acid treatments is sometimes used to increase the drainage area around a well bore in a relatively tight limestone section. This method incorporates gelled high-strength acid normally used as a carrying agent for fracture treatments. Properties of the gelled acid are such that the acid requires time and temperature to break the gel before it can react with the formation. This delayed reaction permits the acid to be forced a long distance from the well bore and results in long channels that greatly extend the drainage area of a well.

Fracturing. Fracturing with any of the available sand carrying fluids should be considered in smaller treatments for its ability to repair well damage immediately around the well bore. But, larger treatments also have the effect of greatly extending the drainage area of a well.

Three broad conditions are usually necessary to obtain good results from a fracture treatment: (1) permeability should be low, (2) the formation should be hard enough to prevent plugging the fracture sand, and (3) the reservoir should have sufficient pressure to move the fluid back into the well bore. Experience will determine the optimum treating volume and rate. Laboratory analysis will usually determine the best sand carrying agents that are compatible with reservoir fluids or formation rock. Sand carrying agents have been known to react with materials in the formations to form hard emulsions, gummy residues or precipitates that reduce the permeability and create considerable damage. If the wrong carrying agent is used, the treatment can result in a loss of productive capacity from the well.

Plugged formation. The use of wetting agents and other allied materials to remove water blocks, emulsions or to reduce bentonitic shale swelling is probably the most unpredictable technique in use at this time. The success ratio of such treatments appear to be very low; but the minor cost of these treatments tends to compensate for the low success ratio.

Well history records in cases of this type of formation damage will usually afford a good clue as to the need of this kind of treatment. A well that is a good candidate usually flows with a good productivity index in its early life until such time as the first small trace of water production is noted. From that moment on, oil production declines rapidly and usually the water production will never amount to more than a barrel or two a day. The decline is so rapid that the well may be flowing 50 bbl of oil per day with good tubing pressure and 12 months after the first trace of water is noted, it may be able only to pump two bbl of oil and two bbl of water per day, while other wells a little higher on the structure may still be flowing their 50 BOPD. Such a case is shown in Fig. 6.

Laboratory tests can be of considerable aid in determining the cause of the trouble; but in many cases results are inconclusive and do not correlate with field observations. In case of doubt, a good axiom to employ here would be to go ahead and treat since the cost involved is small and the benefits that are sometimes obtained may be sizeable.

Where calcium carbonate deposition appears to be plugging the perforations of sand, a small amount of acid eased into the formation at a low rate and with little pressure will usually relieve the situation. However, this treatment usually increases water production to a greater extent than oil produc-

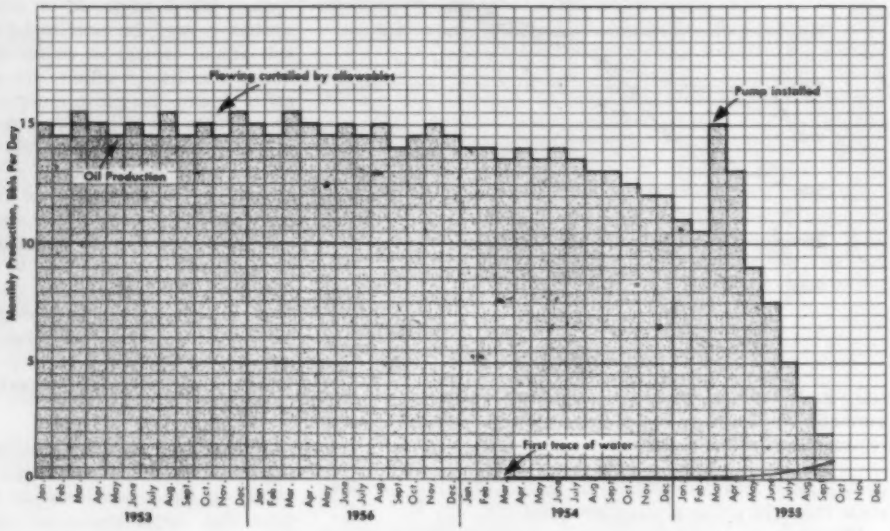


FIG. 6. **Production history** of well plugged by severe case of bentonitic shale swelling to form a permeability block. Note rapid decline in oil production following first trace of water production.

tion, as the calcium carbonate was deposited by the formation water entering the well bore.

Paraffin plugging is caused by a reduction in temperature and possibly in some cases by the loss of a small amount of gas in the oil. Hot oil treatments and paraffin solvents usually will alleviate the problem.

Well Repairs

Repairs are a category of wellwork that usually are expensive and which, in one sense of the word, do not appear to pay a return on the investment. Benefits from such work are generally intangible and include such items as protection of a valuable reservoir or avoidance of a possible law suit. The need for two types of casing repair jobs usually comes so suddenly that little or no planning has been made to do the work, as the first indication of the need for such a job is a blowout or a crater. In some cases, production from a well ceases abruptly. In any event, the quickest way to kill the well, locate and repair the trouble, is usually the best procedure to use as most situations of this kind deteriorate very rapidly with time.

In another instance, quite opposite in character, a leak in the casing in one well in a large partially unitized gas field has been known to waste reserves of 15.5 million MCF without any surface evidence. The leak was first suspected because behavior of reservoir pressures was inconsistent with the volumetrically calculated gas volume. Data available on the performance of this field were studied with the aid of an electronic reservoir analyzer to predict reservoir performance. It was predicted that a lead of 10-15 million CFD existed. The field was shut in and temperature surveys were run in all wells. One well was found to have a severe leak in the casing and was subsequently repaired. Behavior of the reservoir after the repair job substantiated findings of the reservoir analyzer.

Leaks behind the pipe and between non-producing zones are much more difficult to locate and repair. Fortunately, this is a special case that does not occur too frequently. Detection is usually the result of abnormal production behavior in wells producing from the affected zones.

Two types of repairs to shut off produced sand or to prevent sloughing in open hole completions are relatively simple and do not require discussion here.

Recompletions

Recompletion recommendations usually originate with either the reservoir engineer or the geologist and are made after a thorough study of the field. Recommendations in some cases, because of competitive positions, may propose the abandonment of zones that are still capable of producing a considerable amount of oil or gas in order to equalize withdrawals by other operators. These instances will not be too frequent, but they do exist.

The normal recompletion recommendation usually follows declining production and it becomes a question of determining if the next best prospect in the well is worth testing. Drill-stem tests and core analysis are the best sources of information in old wells. But, here again, reservoir and geological correlations have a direct bearing on whether to test or not. Production history of the zone to be tested should also be given careful scrutiny to determine if the old drill-stem test information is still valid, or if the sand lense has been depleted in the meantime by other producing wells.

Deepening to New Horizon

Deepening to a new sand is always an exploratory geological recommendation and should be initiated by either the reservoir engineer or geologist after as much information as is available has been reviewed.

The production man usually concurs with the recommendation, but it is his responsibility to determine if it is feasible to use the old hole. He should be particularly careful that the present pipe is in good condition and is of adequate size to permit drilling and casing to the contemplated depth. Too often after reaching the recommended depth, a second recommendation is made to go a "few feet further;" this is a serious situation that could lead to considerable trouble and expense. It might have been cheaper and better to drill a new well from the surface.

Well Conversions

Conversion of wells is usually part of a major project which entails work on wells to benefit production of other wells in the field. Therefore, an examination of the proper use of the well should be made on a field-wide basis and many times oil wells or gas wells must be given up for the benefit of production in other wells. The hardest task of the engineer in such cases will be to convince the production superintendent that a particular well or wells should be used. The production superintendent usually complains bitterly that the well or wells are the best in his district, and believes it, too.

FIG. 7 Well Work Recommendation

COMPANY INTEREST
100%

☐ Repair ☒ Workover ☐ Conversion ☐ Abandonment ☐ Recompletion ☐ Deepening
(Check One) (New Zone)

[illegible] North Jim Date 3-21-55

Lease H. Kastrop "A" Well No. 3 Field (Strawn) County XXX Area XXX

Elev. 2199 Measured From RDB Tot. Depth 6050 P. B. Depth 6028

Casing: Size 5½ Seat 6049 Perf. from and to: 5968-5976; 5968-6004

Description & Depth: Liner; Packer: Packer @ 5979' type "A" nipple @ 582'

G/O Contact Subsea: Original — Present — O/W Contact Subsea: Original — Present—
Test date

6-22-55 Hours 24 Oil 20.7 Water No Choke 9/64 TP psi 200 GOR 3527 Chlorides — PPM

Reason for Work Recommended Increase production by selectively BHP 1543 Date 6-27-55
fracturing each zone. This will be the first large hi-rate, hi-volume treatment in the vicinity of this well. See attachments describing other successful similar treatments of the same sand in other nearby fields.

Contractor OK Well Service Rate/hr. 18.50 Hrs./Day 10 Days 6½

Detail of How This Work is to be Done By Steps: (Show Type of Fluid That Will be used)

		Rigtime, Hours per step
1st	Kill well w/O.B. mud, rig up preventer & master valve, rlse. pkr, tbg bim.	14
2	Lay down 2" tbg & pkr. Run 3" tbg & pkr. @ 5980'	16
3	Frac 5968/6004, w/ 8000 gal gel crude & 12000# Sand, using FLM	4
4	Pump packer seal plug, unlatch pkr, pick up 2 joints	2
5	Frac 5968-76 w/80000 gal gel crude & 12000# Sand, usingFLM	4
6	Kill well w/OB mud, wash over pkr, latch on, pull seal plug, pull tbg.	10
7	Re-run 2" tbg w/o pkr. for completion, swab test.	15
8		

COST ANALYSIS Total $

(Show Service Co; Kinds & Grade of Material)

Haul		DST & HWP Tests	
2-500 bbl Tanks	$ 200	Dress Packer	$250
Derrick		Fluid Loss Mat'l	208
Fuel		Gell & Sand & Drayage	1200
Water		Acidize	
Mud 30 bbl Oil Base Mud	330	Fracture	
Rig Move		Plastic	
Teaming (Pipe, cement, etc.)	317	Cement	
Bits		Bridge Plug or Retainer	
Rig Time 65 hrs. cost per hr.	1202	Other Blender	150
Company Labor	150	3-"A" Pumps	1475

Prepared by: C. J. K. Estimated Total Cost $5482

Area Supt. Signed: K.L.M. Date: 9-27-55

District Engr. Remarks:

Signed: B. C. D. Date: 9-29-55

District Geo. Remarks:

Signed: W. L. Date: 10-3-55

District Supt. Remarks:

Signed: A. C. C. Date: 10-7-55

Dallas Geological Dept.

Signed: C. C. H. Date: 10-10-55

Production Engr. Dept. Area and District agree by Teletype to increase treating volume to 15,000 gal & 30,000# per stage. Total cost will then be apx. $6000.

Signed: B. J. R. Date: 10-13-55

Production Supt.-Instructions APPROVED for 15,000 gal & 30,000# stage treatments.

Approved: I. R. L. Date: 10:13:55

(1) History

Give completion date; Initial, last & cumulative production for well and for lease if indicated. Show data for both zones of dual well. List previous W/O's, date, purpose, procedure, with production before and after. State reason for recommending this particular procedure and materials. I.P., 5-30-53, was 93.78 BOPD, no water, T.P. 190 psi, ¼" choke, GOR 1625/1. Well during completion was perforated 5968/76' and fraced w/2000 gal No. 5 fuel oil and 1600# sand; killed well w/mud, pulled packer, perforated 5968/6004', ran tubing and packer and Otis eqpt. Washed around, attempted to frac, 5968/6004', w/2000 gal. No. 5 fuel oil. Packer failed twice. Killed well each time w/mud. Fraced on 3rd attempt. Tested. Acidized 5968/76' w/500 gal. Cumulative production to date: 29,547 oil, 94,758 gas, and no water.

Repeated killing of well with mud has damaged upper formation. Large, selective frac treatment should remedy this situation. Use of oil base mud should also tend to prevent same trouble from reoccurring on this treatment.

(2) Geological Infromation

(Position on structure, sand conditions, presence of other sands, relationship to other wells.) Submit farm platt or field map; and when warranted, geologic cross section or structure map.

Top Strawn Sand—3789, Bottom—3781
Top Strawn Sand—3798, Bottom—3809

No evidence of Gas/Oil or Oil Water contact available. Present high GOR probably caused by limited production and gas breaking out of solution at low owing pressures.

(3) Lease Status

Effect of this recommendation on lease, effect of abandonment of this zone, relation to offset wells, Sun position in field. Give lease number. Show maximum and calender allowable for field and wel, No. of wells and daily production for the field or unit.

Lease No. [illegible]

Top field allowable is 102 BOPSD or 56 BOPCD with GOR limit of 2000/1. Company has 12 of the 18 wells in the field and is producing apx. 75% of the oil.

(4) Economics

State what W/Wis expected to accomplish in increased production, labor or material savings. What is expected payout If abandonment, list anticipated salvage at new value, along with expected labor savings, etc.

This large volume treatment should indicate if the other six Company wells not presently producing top field allowable can be benefitted by a similar treatment. If production is increased to 56 BOPCD, payout @ $2.00 per bbl extra revenue will be $2.00 x 26 or $52.00; $5482 ÷ $2.00 = 105 calendar days.

(5) State Regulations

(Indicate reports prepared, or to be prepared, to cover work proposed.)

☐ Form 3 Repotential.

FIG. 7. **Typical recommendation** for well work on a workover so that all interested and effected suggested form for handling all necessary data and proposals on a departments can give proper study and approval.

Determining Procedure

One approach that will greatly aid in determining the best procedure to use for a particular well is to fill out a wellwork recommendation form. Use of the form is beneficial in several ways. If the form is properly filled in, it requires that the engineer be familiar with the characteristics of the particular well and sand and insures that he has given the work considerable thought. The form will also aid in setting up a logical sequence for the procedure and estimating the time and expense involved. A copy of one wellwork form is included as a suggestion. Many other comparable forms are in use and all are of assistance if they are properly filled out.

In addition to the approval required on the form, the proposal is reviewed by many others who represent interested departments. If there appears reason to do so, the form is also passed to the following groups: Reservoir Engineer, Title Record, Legal, Division Land, Gas Department, Part Interest, Proration and State Rules, Material Equipment Section, Material Expeditor, Division Production Superintendent and Division Manager for their comment or approval. The rule to apply here is to request every competent person who has important information to review the proposed work to make certain that complete consideration has been given to all possible factors.

This procedure prevents telephone approvals for work and insures that the fullest possible consideration has been given to the success of the job; and if there are hazards and risks involved, they have been given due consideration. ★ ★ ★

SPECIAL Well Workover FEATURE

Reservoir Fundamentals Are the Basis for . . .

The Analysis of PROBLEM WELLS

A production man's explanation of problems dealing with:

(1) well pressures;
(2) water production; and
(3) gas production.

Norman J. Clark and W. P. Schultz
Core Laboratories, Incorporated, Dallas, Texas

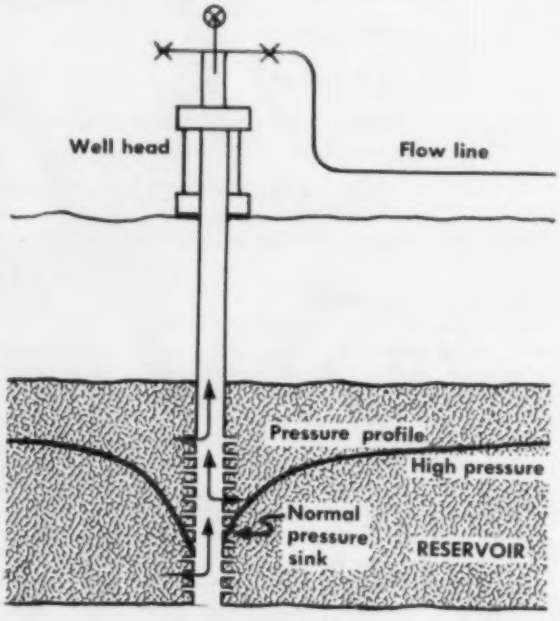
OIL and gas wells are expensive faucets that enable production of depletable petroleum reserves. A prudently planned initial well completion program is, therefore, the first and most important step in obtaining long trouble-free producing well life with a minimum amount of costly well workovers to attain recovery of reserves. An optimum initial well completion program results in completions not only based on geologic conditions occurring in the reservoir at discovery, but also upon changes to the physical make up of the reservoir adjacent to the well occurring at the time the drill penetrates the reservoir, the changes occurring in the fluid saturations brought about by fluids flowing at a later date, and many mechanical problems with equipment of the well itself during production operations.

It is certainly desired to attain a well completion that will not require future workovers, but conditions are often met where workovers are required to correct conditions which, at the time of initial completion, could not be foretold. In many cases workovers may be forecast as a future requirement in any optimum well completion program. A workover of a well is the attempt that is made after initial well completion to establish or restore a problem well to some desired producing capability. The definition of a problem well is quite arbitrary as it depends upon such things as the capability of the well and reservoir to produce efficiently, how much production is allowed by the regulatory body involved or, if a mechanical problem is involved, the nature of such problem. It is not within the scope of this paper to cover the well production problems dealing with mechanical equipment or with such problems as sanding or paraffin deposition. Instead, this discussion will deal with the lithologic and reservoir mechanic aspects that are so often the basis for problems of producing wells. A very general definition of a problem well therefore, may be stated as one that does not make its desired or allowed production or, in doing so, requires otherwise unnecessary waste in reservoir energy or costs.

A well should be drilled and completed to most effectively utilize the natural reservoir energy and lithologic configuration of the reservoir rock in recovering the oil. The basic reservoir considerations involved in planning a workover are the same as those involved in planning the initial completion, and it is with these reservoir considerations that are of concern here.

The symptoms of problem wells may be grouped into three broad types: (1) well pressure problems, (2) water produc-

FIG. 1. **Pressure sink** normally occurs at the well bore of flowing wells as indicated by the pressure distribution curve above.



The Authors

Norman J. Clark is assistant manager of the Engineering and Consulting Department of Core Laboratories, Inc., of Dallas, Texas. He received a BS degree in petroleum engineering in 1941 from the University of Oklahoma, and began his engineering-training with Humble Oil & Refining Company as a roustabout in Southwest Texas. After 3½ years in the Navy's Bureau of Ordnance during World War II, he returned to Humble. He specialized in reservoir engineering studies, developed and supervised reservoir engineering training schools, and set up and coordinated a company formation evaluation program. He joined Core Lab in June, 1955. He is a member of AIME and a registered professional engineer in Texas.

W. P. Schultz is a senior petroleum engineer in the Engineering and Consulting Department of Core Laboratories, Inc., in Dallas, and was graduated from Rice Institute in 1947 with a BS degree in chemical engineering. For two years following graduation, he worked with Humble Oil & Refining Company in the field, then was transferred to the Houston office where he was engaged primarily in general reservoir engineering work. He also instructed engineers and field supervisors in reservoir engineering. He joined Core Lab in June, 1955. He is a junior member of AIME and a registered professional engineer in Texas.

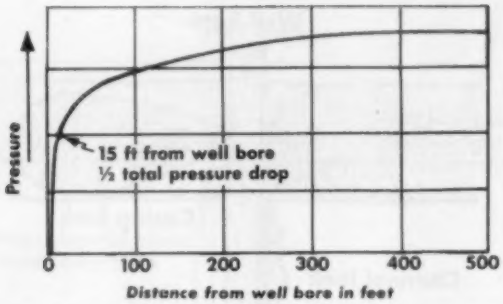


FIG. 2. **Pressure drop** within 15-ft radius of flowing well bore is about one-half of the total pressure drop measured from a 500-ft radius of the well bore.

tion problems, and (3) gas production problems. Although many well troubles result from other circumstances, it is of interest to note that these three symptoms are commonly associated with dissolved gas drive, water drive, and gas cap drive reservoir producing mechanisms, respectively.

Pressure Problems

When reservoir pressure falls, an immediate problem for the flowing well may be one of reduced well production rates to create an economic problem that may be solved by a workover. Oil has little inherent ability to produce itself into a well bore. It is produced principally by energy associated with pressure that is derived from gas dissolved in the oil and that expands upon liberation as pressure is reduced in the reservoir; by free gas that is associated with the oil column as a gas cap and expands downward as reservoir pressure drops; and by water that expands into or otherwise enters the reservoir as reservoir fluids are removed and reservoir pressure drops.

Of great significance in the interpretation of well problems caused by adverse pressure conditions is the actual occurrence of pressure and what causes it to vary and change with reservoir production and production history.

Radial flow. Because fluids move to the well bore from all directions, the term "radial flow" is given the flow mechanism, and because the well thus forms a restrictive point of fluid movement, a substantial pressure drop or "sink" occurs at the well as shown in Fig. 1. This occurs even with permeability being uniform throughout the reservoir rock. It is significant that under such conditions about 50 per cent of the total pressure drop within a 500-ft radius of the well will occur within about 15 ft of the well itself (see Fig. 2). Reservoir

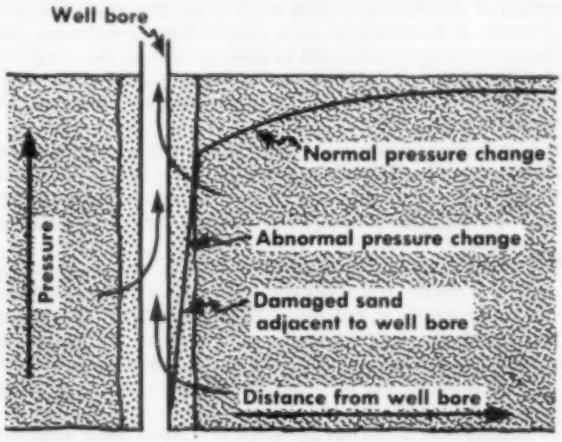


FIG. 3. **Abnormal pressure drop** across damaged sand in a flowing well is illustrated qualitatively by the pressure distribution curve around the well bore shown above.

pressure, therefore, must be sufficiently high to overcome not only such things as weight of the producing column, pressure drop in the tubing flow lines and separator working pressure, but also excessive pressure restrictions around the well.

Bottom-hole pressure. Low flowing bottom-hole pressure in a reservoir having uniform permeability and fluid characteristics and otherwise high average shut in pressure is caused by such things as low reservoir permeability or high oil viscosity. Knowledge of such conditions is determined through core analysis and fluid analysis on a reservoir-wide basis. Low flowing bottom-hole pressure many times is caused by restrictions in permeability adjacent to the well bore caused by the drilling or producing operation. This is an unfortunate circumstance because it is at this point in the reservoir that any restriction is greatly magnified in effect. Fig. 3 illustrates this effect which is termed a "skin effect." This condition may be caused by such things as clay swelling from contact with fresh water filtrate, drilling muds, mud cake penetrating into and sticking to the formation wall in the well, bit glazing of

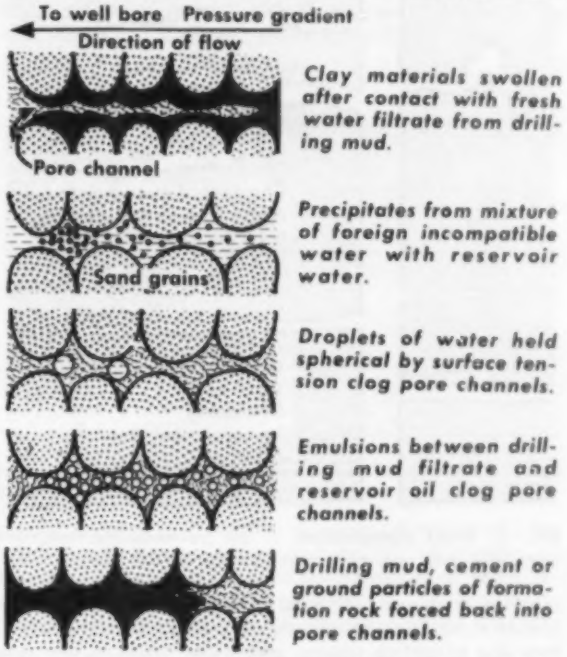

To well bore
Pressure gradient
Direction of flow
Pore channel
Clay materials swollen after contact with fresh water filtrate from drilling mud.
Sand grains
Precipitates from mixture of foreign incompatible water with reservoir water.
Droplets of water held spherical by surface tension clog pore channels.
Emulsions between drilling mud filtrate and reservoir oil clog pore channels.
Drilling mud, cement or ground particles of formation rock forced back into pore channels.

FIG. 4. **Reservoir conditions** causing the so-called "skin effect" are shown in simplified form above. These are the four basic causes.

the well bore, water blocking the pore channels adjacent to the well bore, etc. (see Fig. 4).

There are so many individual or combinations of conditions that cause a skin effect that it is somewhat difficult to interpret the problem and solve it without some trial and error with methods of well stimulation. Many operators go completely along the trial and error route; however, careful reservoir study can save greatly in time and cost. An approach to a determination of the effects of fresh water on well productivity can be made by running permeability tests on cores in the laboratory using varying salinity waters and measuring the deleterious effects on permeability caused by the fresh water. Results of such studies may indicate the need for drilling future wells with salt water, oil base, oil emulsion, or perhaps a special low water loss mud.

The term "water blocking" is applied many times indiscriminately to many skin effect problems, including such things as the reduction in relative permeability caused by precipitates that form when some foreign incompatible water contacts formation water in the pore channels at the well bore, thus

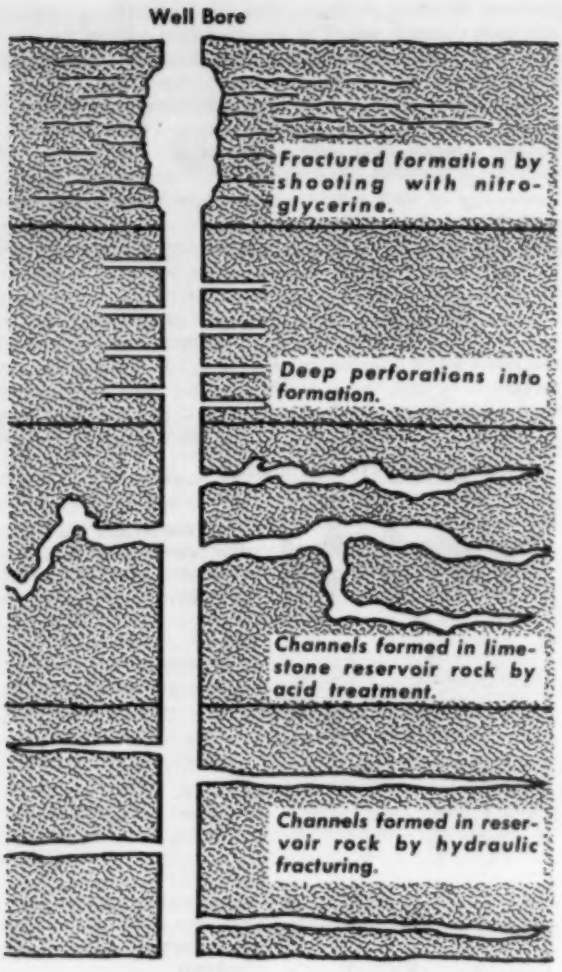

Well Bore
Fractured formation by shooting with nitroglycerine.
Deep perforations into formation.
Channels formed in limestone reservoir rock by acid treatment.
Channels formed in reservoir rock by hydraulic fracturing.

FIG. 5. **Well stimulation** in low permeability reservoirs may take any one or a combination of the above forms.

blocking or clogging the passage ways for oil flow; by droplets of water being held in the pore channels near the well bore due to surface tension; and, by an emulsion that may form between mud filtrate water and in-place crude oil.

Ordinarily if the reduction in permeability causing the skin effect can be identified, treatment to restore the permeability can be effected. Such treatment may be performed with surface tension breakers, emulsion breakers, acids, or by a combination of treating materials.

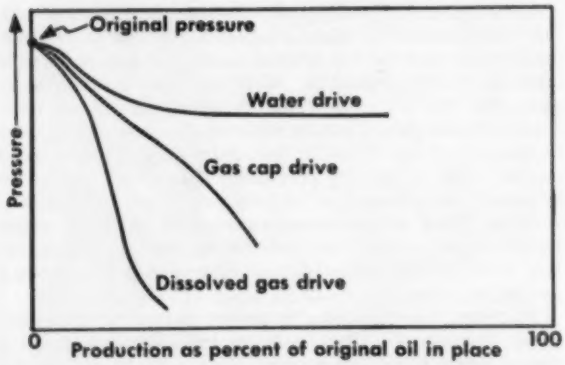


FIG. 6. **Characteristic reservoir pressure history** for the different type drive mechanisms.

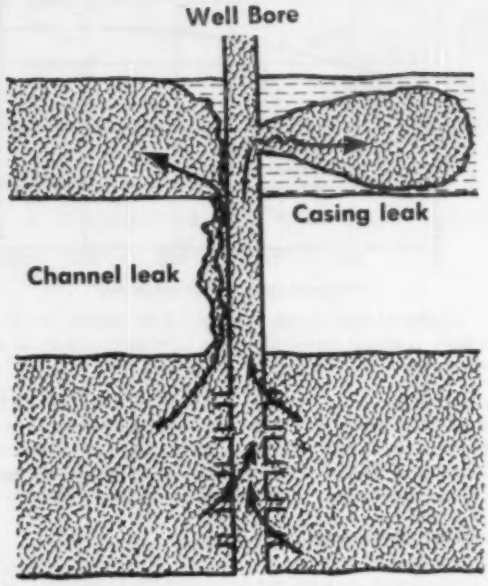


FIG. 7. **Low bottom-hole pressure** caused by loss of oil to low-pressure thief water sand.

Stimulation of wells completed in very low permeability formations to drastically increase permeability in the volume of reservoir rock extending to some distance out from the well bore has been practiced for many decades. These practices include shooting with nitroglycerin, deep perforating, acidizing, and more recently, by hydraulic fracturing with oil, acids, and other fluids. (See Fig. 5). Good core and log analyses are essential to an intelligent study of well work leading to improvements in well productivities under these conditions.

The reservoir drive. The reservoir drive mechanism itself has a direct bearing on how long reservoir pressure can be maintained out in the reservoir proper and thus result in maintenance of high producing bottom-hole pressure. Reservoir pressure in dissolved gas drive reservoirs drops rapidly and continuously (see Fig. 6) and workovers ordinarily are necessary to install lift equipment in addition to any attempt to increase productivity for any extended period of time. Identification of dissolved gas drive early in the producing life of a reservoir is necessary in order to plan well completions and workover programs that will be most suitable for the reservoir. Benefits of early injection operations are sometimes lost in this type reservoir if pressure is allowed to drop very much before injection is started.

Reservoir pressure in a water drive characteristically remains high throughout the producing life of the zone. Some reservoirs having this type drive mechanism can show a reservoir pressure increased when the oil production rate is decreased.

As indicated in Fig. 6, the bottom-hole pressure in a gas-cap drive reservoir declines continuously with oil production, but not so rapidly as with dissolved gas drive reservoir. A complete study is required to properly identify the producing mechanism and such study must utilize a considerable amount of core analysis, log, fluid analysis, pressure, and production data.

Bottom-hole pressures for wells in a water drive reservoir may become abnormally low because of such defects as channel leaks or by casing leaks, both cases of which may result in reservoir fluids being lost to low-pressure thief sands (see Fig.

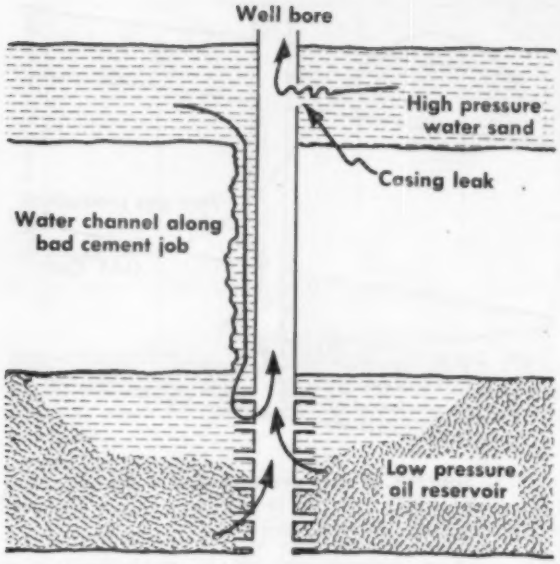


FIG. 8. **Water channel and casing leak** causes entry of water from high-pressure water sand to low-pressure oil sand and to produced oil column.

7). Pressure anomalies are in most cases the first evidence of such occurrence and workovers to shut off such leaks are usually guided based on pressure and temperature surveys.

Water Production Problems

Water production is costly both from the standpoint of lifting the produced water to the surface and then disposing of it. It must be remembered, however, that maximum recovery from water drive reservoirs requires a large amount of water to move through the sand, and thus large quantities of water production from the reservoir may be required eventually to assure maximum oil recoveries. The operator therefore, must not "run from water" or, for that matter, work wells over to exclude water unless careful reservoir study indicates it to be economic, for there are many sources of water other than the water drive of the reservoir itself. An example is channeling of water along a bad primary cement job from a high-pressure water sand to the lower pressure oil producing sand. Also, leakage of water may occur through the pipe and into the producing fluid. In both cases (see Fig. 8) water contributes nothing toward flushing oil from the producing reservoir, and well workovers are usually required to shut off the stray water production. Well logs, water analysis, and temperature surveys are among the important data required in studies of such well problems.

Water coning and fingering. High rates of oil withdrawals from individual wells tend to create an abnormally low pressure area around the wells. If such wells are located low on the structure and near the water level, water will tend to be drawn up across the bedding planes of a homogeneous sand into the well as a "water cone" (see Fig. 9) or drawn up along the bedding planes of a stratified sand into the well as a "water finger," see Fig. 10.

Fingers and cones may form as a result of high withdrawal rates even though well completions are substantially above the water level and, once established, these fingers and cones may become quite stable or persistent because of reduction in relative permeability of the sand to oil created by the high water saturations adjacent to the well bore. Thus, water

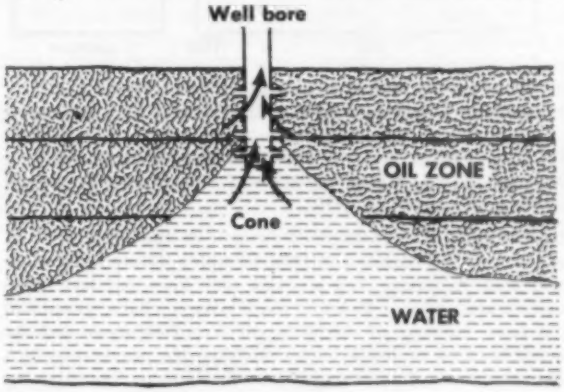


FIG. 9. **Water cone** formed into producing well resulting from excessive producing rates.

production may be caused by improper rates of production which can be improved in some cases only by reducing allowables or shutting in the wells and permitting oil and water to segregate back to their normal level.

In other cases, it may be desirable to work the well over

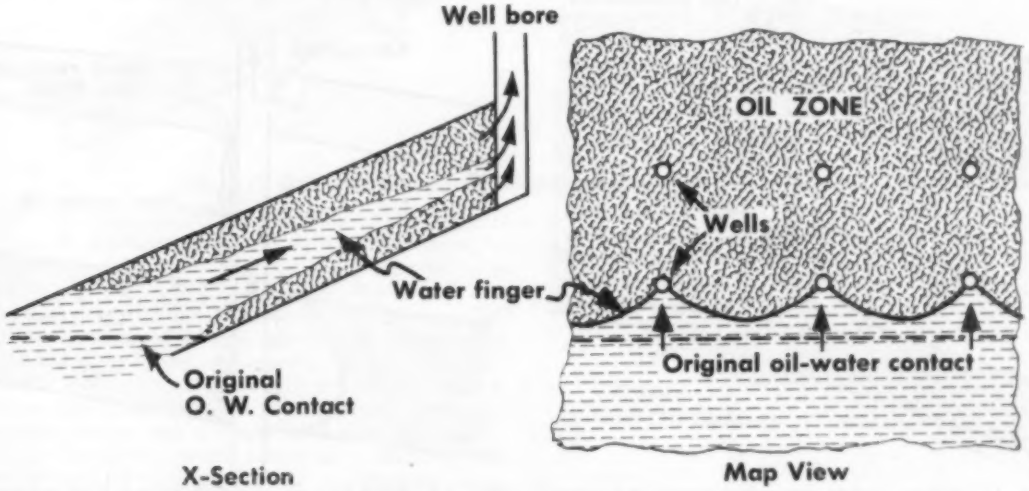


FIG. 10. **Water fingers** formed from water basin to producing wells through more permeable streaks in producing formation.

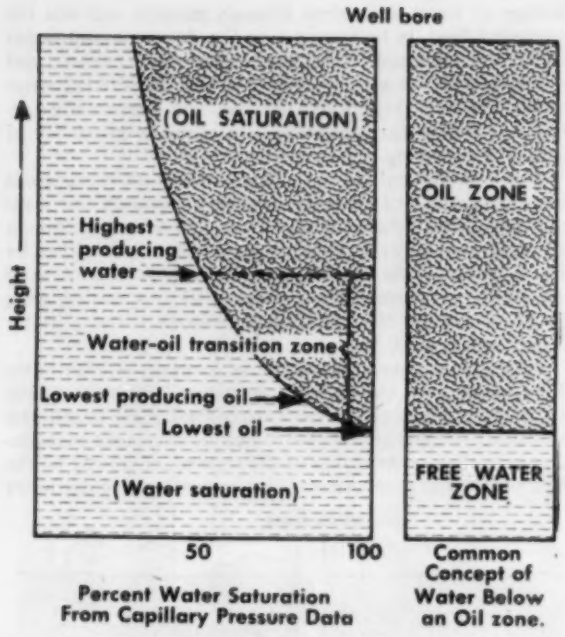


FIG. 11. **Water-oil transition zone** defined as the zone between lowest oil and highest producing water and based on capillary pressure data.

and recomplete it in another stringer of the same zone or another zone if such is available. Complete formation evaluation data, including core analysis, well logs, and test information are required to know the lithologic characteristics of the zone, location of the water-oil transition zone, and the quantity of oil originally down dip from the problem well. A reservoir study of pressure-production trends to determine the distance the water should have moved into the reservoir as a result of past production is necessary to ascertain whether or not a workover could be expected to result in improved well performance.

Many times a well penetrates the oil reservoir very near the

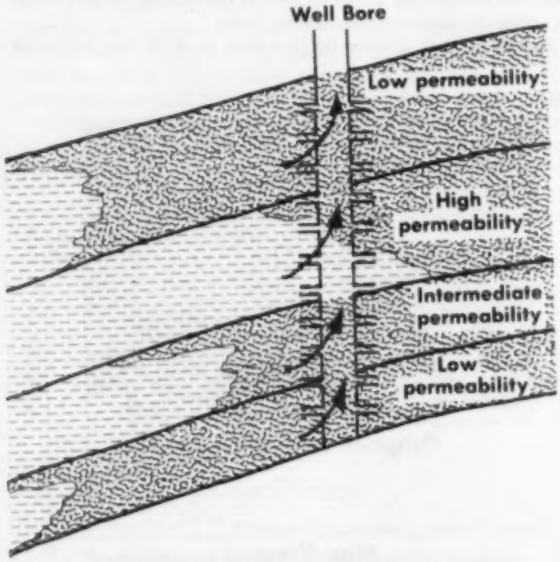


FIG. 12. **Irregular water encroachment** and premature water breakthrough in high permeability layers of reservoir rock.

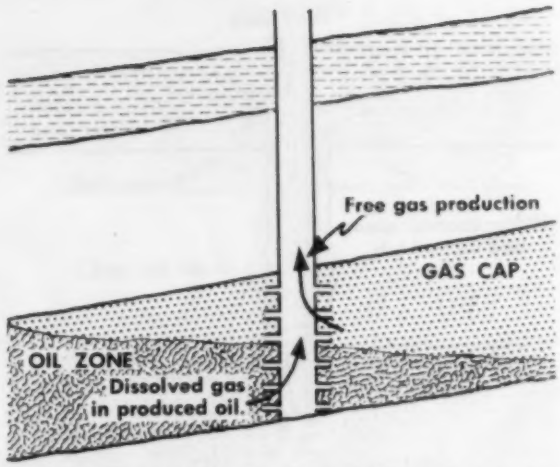


FIG. 13. **Sources of gas produced with oil** are as indicated above: (1) free gas production; (2) gas cap gas, and (3) dissolved gas in produced oil.

free water level and the result may be a high percentage of water production on initial potential test. Needless expenditure of money by the operator in workovers is often the result unless proper analysis of the situation is made immediately upon which to guide the job.

Free water level. The oil-water contact is not a level plane in the reservoir at a specific depth; far from it, as there is a zone of transition from the level of 100 per cent water saturation up into the oil bearing zone and all the way through the zone to the top. The proper term "original transition zone" or the so called original "water-oil contact" is applied to that portion of the reservoir above the free water level between the points of lowest oil and highest producing water (see Fig. 11). In this zone there occurs a rapid decrease in water saturation with distance above the free water level. Recompletions of wells in the transition zone through simple workover procedures cannot be expected to make a pipe line oil producer unless the recompletion can be made sufficiently far from the free water level.

Geometry of the pore spaces in the rock, surface tension between the fluids, difference in density between the oil and water, and wettability of the rock establish the distribution of the two fluids in the rock interstices, and thereby control the

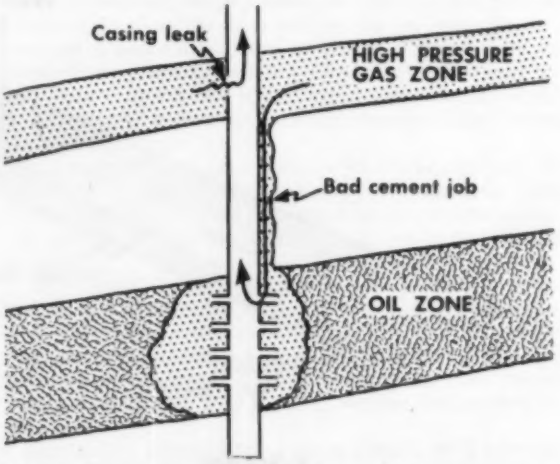


FIG. 14. **Free gas production** from a high pressure gas zone through a casing leak and by way of a channel through a bad cement job.

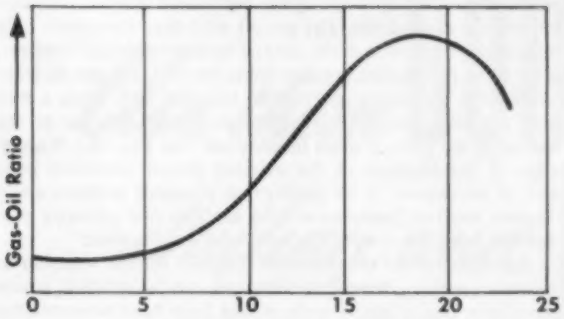


FIG. 15. **Generalized gas-oil ratio history** for a dissolved gas drive reservoir. Note how the gas-oil ratio drops off after about 20 per cent of the oil in place has been produced.

vertical thickness of the transition zone. Water and oil saturations as a function of height above the free water level, which are determined from laboratory capillary pressure measurements of cores from the reservoir in question, and densities of the in-place fluids are used to evaluate the thickness of the transition zone and determine the likelihood of obtaining successful well workovers to exclude water production.

Stratified permeability. Frequently the reservoir is composed of overlying sand beds of different permeabilities separated by layers of shale such that water advances at different rates through different sand beds (see Fig. 12). Even though early break-through of water in the high permeability beds may not cause premature abandonment, a large volume of water must be produced before the oil is depleted from the other beds. It is an economic question, therefore, whether to complete in the beds one by one with attendant high workover costs or complete several simultaneously and increase high lifting costs. Prudent original development of a water drive reservoir, assuming lease committments can be met, would be to locate wells in the reservoir such that efficient allowed production rates could be maintained for a major portion of the depletion period with a minimum number of workover operations. Usually this would consist of completing wells structurally high, for a given continuous sand member.

Gas Production Problems

Production of gas from an oil producing well comes from either or both the gas originally dissolved in the reservoir oil at high pressures, and the free gas that has, during geologic time, segregated and become trapped above the oil as a gas cap (see Fig. 13). Free gas production may also come from a high-pressure gas zone separate from the oil reservoir through channels in bad cement jobs or casing leaks (see Fig. 14).

In the dissolved gas drive reservoir some gas originally in the oil is liberated from solution as oil production occurs and reservoir pressure drops. Further liberation and expansion of free gas is a requirement for primary oil recovery from a reservoir of this type. The increase in gas saturation, however, as oil withdrawals continue, permits gas to flow toward the low-pressure areas at the well bores and be produced along with oil and its solution gas. After production proceeds to some point, the relative permeability of the rock to oil diminishes rapidly and gas becomes the predominant fluid moving. This usually occurs before 15 to 20 per cent of the original oil is recovered from the reservoir (see Fig. 15.) High ratio production in cases of this nature is usually not a well problem at all, but instead is a problem of the reservoir as a whole.

Working wells over or transferring allowables of very high ratio wells to low ratio producing wells may result in some decrease of excessive gas production. However, both cases can be expected to provide only temporary improvement unless unusual factors are present and advantage can be taken from them.

If the reservoir has considerable dip, high permeability, and low oil viscosity, production can be concentrated in the down-dip area of the reservoir and reservoir gas-oil ratio reduced by permitting the gas to segregate up the structure away from

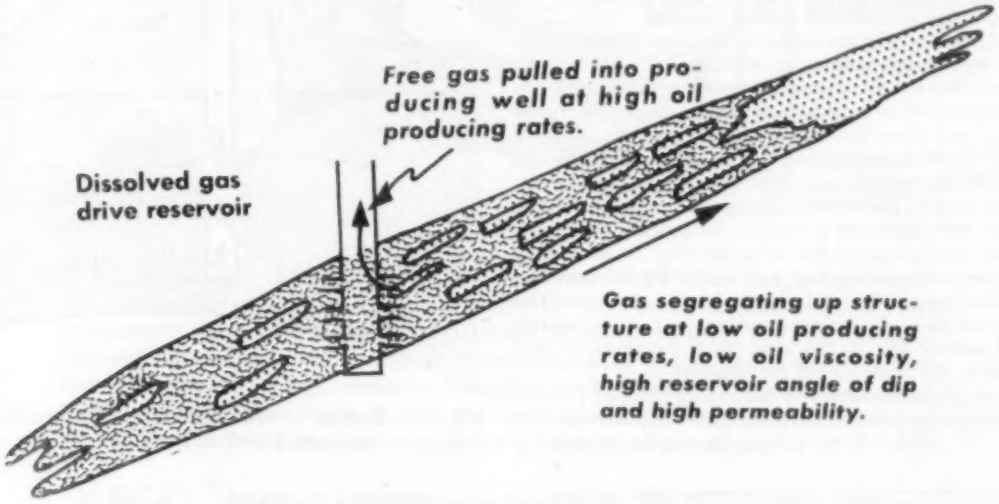

Free gas pulled into producing well at high oil producing rates.
Dissolved gas drive reservoir
Gas segregating up structure at low oil producing rates, low oil viscosity, high reservoir angle of dip and high permeability.

FIG. 16. **Gas and oil segregation** in dissolved gas drive reservoir.

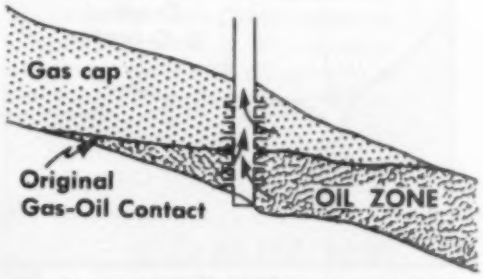


FIG. 17. **Gas produced** direct from the original gas cap through an improper well completion where the gas cap was perforated as shown.

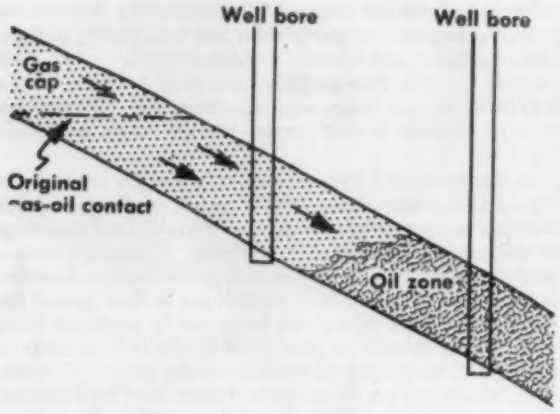


FIG. 18. **Expansion of gas cap** in a gas cap drive type reservoir causes the gas-oil contact to move past oil producing wells located high on the structure.

the area of oil withdrawals (see Fig. 16). This, however, depends upon the rate of oil withdrawal and the corresponding rate at which the gas will move away from the influence of the well. Prudent original development of the reservoir other than those necessary to meet lease committments would have been to locate wells in the reservoir to accommodate such a reservoir behavior and limit the wells to only those needed to take the oil withdrawal which the reservoir could support at allowable rates of production. Such a development program is based on rapid and accurate interpretation of core analysis, logs, well tests, and reservoir fluid analysis combined with a deliberately slow and planned drilling program.

Loss of gas-caps. The production of oil from a gas-cap drive reservoir depends upon the energy available in the compressed gas that overlies the oil column. Oil production permits pressure to drop in the oil zone and allows the gas cap to expand downward and along the bedding planes into the oil zone, driving oil ahead of the moving free gas front. It is desirable to conserve the available gas-cap energy for purpose of displacing oil, and its production is recognized to be wasteful to the extent that allowable reductions in prorated reservoirs may result in an economic loss to the operator. Production of gas-cap gas can lead to serious reservoir problems, including gas-cap shrinkage, if the reservoir also has a water drive. This situation can lead to large losses in oil recovery by oil moving into and wetting the dry gas sand. Such problems are best diagnosed by detailed study of the reservoir.

Gas cap gas production may be coming through perforations completed in or above the original gas-oil transition zone (see Fig. 17). Such a faulty completion may be remedied at least temporarily by lowering the perforated interval if sufficient section is available. The gas-oil ratio may have been only dissolved gas-oil ratio at the date of well completion; however, after some production is taken from the well, the gas-oil transition zone may have encroached into the well. Such a well may not be capable of repair by workover because of the nature of the gas-cap drive mechanism (see Fig. 18). Knowledge of the location of the original gas-oil transition zone and its movement as oil production proceeds requires study of core analysis, logs, tests, fluid analyses and pressure production histories of both the wells and the reservoir.

A prudent initial development program for the reservoir as a whole assuming lease committments can be satisfied, would have been one whereby wells would have been concentrated low on the structure recognizing that the gas cap would, by expanding toward the high wells, encroach into these wells and result in their turning to high gas-oil ratio producers.

Gas cap coning. Gas-cap gas coning down across bedding planes (see Fig 19) and fingering down along bedding planes (see Fig. 20) often occur in areas of excessive withdrawals near the gas cap. What may be excessive oil withdrawals in one reservoir situation may be entirely satisfactory in another reservoir situation. Predictions of coning and fingering tendencies of the reservoir may be based upon data concerning the magnitude and variation of permeability of the reservoir rock.

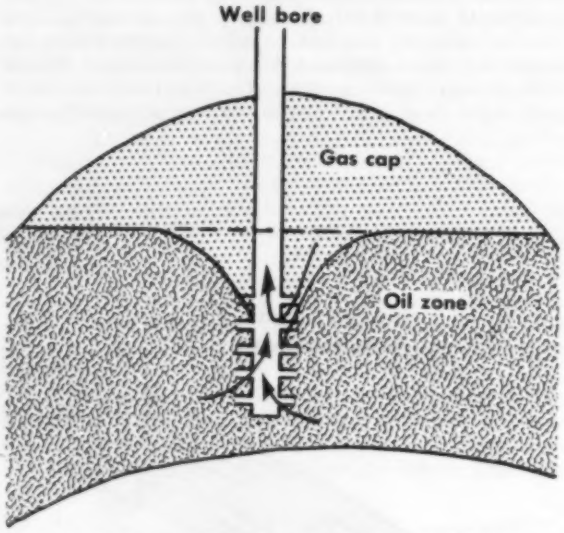


FIG. 19. **Coning of free gas** across the bedding planes into an oil-producing well located high on the structure.

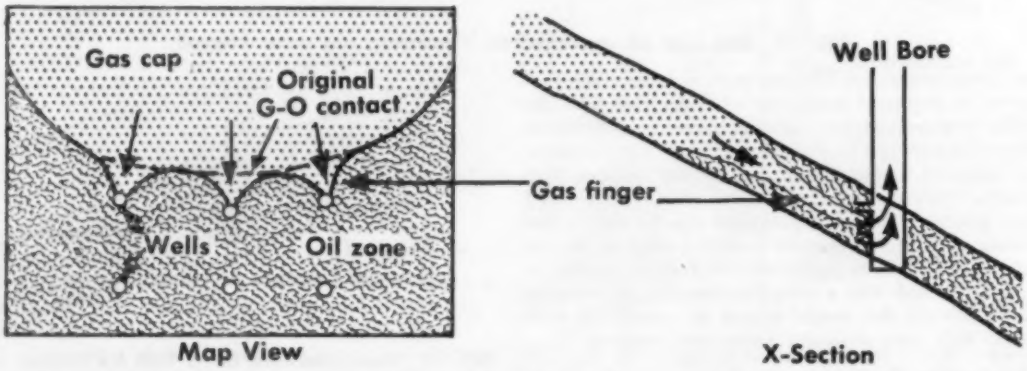


FIG. 20. **Fingering of free gas cap gas** into oil-producing wells located high on the structure.

Use them **BOTH** *to reduce drilling and completion costs!*

DRISCOSE* saves time, saves money! DRISCOSE, a high-stability, high-purity CMC (99.9%), allows you to control water loss, viscosity and gel strength for optimum drilling conditions. At the same time, low pH, low solid DRISCOSE emulsions give you higher penetration rates. You save on operating time and on expensive bit replacements. DRISCOSE also helps avoid tight hole troubles. Consult our technical representative about your particular mud problems. Let him prove that DRISCOSE can save you money on your mud program.

DIACEL CEMENT SYSTEMS can save up to ¾ of the cement ordinarily required.** Using ordinary portland cement, you can control water loss and thickening time with a DIACEL Cement System. Versatile DIACEL systems give you a choice of densities from 10.5 to 17 pounds per gallon . . . to suit wells of all depths and wide temperature range. You can save up to 25% on cementing costs and get better drilling and completion work with a DIACEL System. Write for free technical handbook or call our technical representative.

*Driscose is a trademark for 99.9% pure Sodium Carboxymethylcellulose.

**A TRADEMARK

DRILLING SPECIALTIES COMPANY

BARTLESVILLE, OKLAHOMA

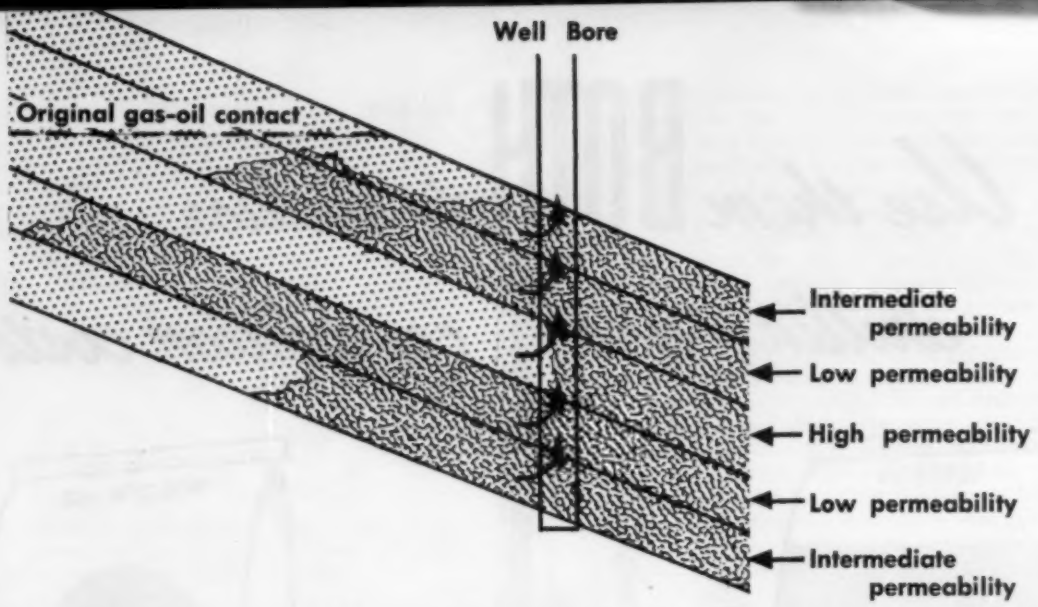


FIG. 21. **High gas-oil ratio production** caused by early encroachment of gas through high permeability zones of stratified reservoir.

Reservoir stratification. The nature of reservoir stratification is extremely important in maximum ultimate displacement of oil by the expanding drive of the gas cap. It is important to withdraw oil from all separate permeable layers of rock to permit the gas cap to expand through the individual layers and deplete the recoverable oil from each. In one sense it would be desirable to make a long completion interval across all the permeable sections; however, one separate section having high permeability may permit the expanding gas to reach the well bore very rapidly and cause high ratio production before the other sections are depleted (see Fig. 21).

On the other hand, it may be desirable to complete the well in only one permeable interval at any one time. However, many workover jobs may result from this choice of completion program. The original development program should, therefore, not only reflect careful study of the lithology through examination of core analysis and log interpretation, but also careful interpretation of the reservoir drive mechanism so that future operations will minimize work over expenditures.

Problem Gas Wells

Many types of problems are associated with the production of gas, the principal ones being pressure, water production, hydrate formation, and retrograde condensation. Many of these, such as reduced well capacity caused by reservoir pressure drop or low formation permeability, are problems associated with skin effect, water coning and water fingering have already been discussed. One gas well problem usually not associated with oil wells is that of hydrate formation. This is actually a temperature problem whereby hydrocarbons and water in the producing stream from solid components that deposit in the surface equipment and either restrict or shut off the flow of gas. Careful analysis of the situation will enable an operator to employ producing practices that do not permit hydrate formation.

Retrograde condensation. Another problem associated with gas wells is that of retrograde condensation. This is not a well problem but is a pressure problem characteristic of certain gas reservoirs. When reservoir pressure declines in a gas reservoir that contains a considerable amount of heavier hydrocarbon components, liquid condenses in the reservoir and such liquid can represent a considerable economic loss. As the problem is brought about by pressure decline in the reservoir. it likewise can be avoided by not permitting such pressure decline.

Many gas reservoirs are today being cycled just for this purpose. Cycling consists of injecting back into the producing zone, according to some predetermined injection-production patterns, gas that has been produced and processed such that reservoir pressure is maintained at a high level. The economics of such operations can be evaluated by thorough reservoir study based on such factors as reservoir geometry indicated by core analysis and well logs, on reservoir fluid characteristics including retrograde properties of the gas, and on producing characteristics of wells.

Proper Interpretation of Behavior

Occurrence of problem wells from a reservoir standpoint are generally classified as to problems resulting from inadequate producing well bore pressures caused by low reservoir pressure or abnormal restrictions in the flow channels from the reservoir proper and the well bore; from water production the sources of which are the water basin in the oil producing strata and below the oil zone or some foreign strata; and, from excessive free gas production, the sources of which are the gas cap in the oil producing strata above the oil zone or some foreign strata.

The occurrence of oil, water, and gas, the distribution of these fluids in the rock strata and in the reservoir itself, the permeability regularity of the rock strata particularly in the reservoir, and the physical nature of the fluids govern the reservoir producing mechanism which in turn governs the characteristics of the producing wells. Locating the source of trouble in problem wells, therefore, requires proper interpretation of the reservoir behavior. If the problem well reflects a problem reservoir, improvement of the well may not be accomplished by a workover.

Minimum well problems are to be anticipated in reservoirs that are developed by a prudent drilling program based on interpretation of good reservoir data including core analysis, log interpretation, fluid analysis, pressure, and production information. This would indicate slow and deliberate development so that reservoir geologic and behavior information could be used to guide drilling the wells. From the standpoint of the reservoir, the number of such wells would be limited to only those necessary to take the reservoir rates of oil production desired or allowed that would not exceed the reservoir's capability to produce efficiently, and from the location in the reservoir to minimize problems of the producing wells.

* * *

SPECIAL Well Workover FEATURE

Comprehensive Report on . . .

Permanent Type Completions And Wireline Workovers

Latest word for the practical production man on the biggest cost-saving idea to hit the industry in a decade. What permanent type completions are and how they work. How to do wireline workovers . . . analysis of of actual field costs . . . new developments . . . etc.

Gilbert H. Tausch and Price McDonald
Humble Oil & Refining Co., Houston, Texas

As an example of the increased success of the permanent completion method, jobs were performed in the Texas Gulf Coast area during 1953 at an average cost of $3200 per recompletion attempt. Much of this work was performed on relatively shallow wells where conventional costs were low and the permanent completion costs were estimated to be 91 per cent of the cost of doing the same work with a rig. **In 1955, however, with a vast backlog of experience in working on deeper wells at an average depth of 7000 feet, it was possible to reduce the average job cost to $2900 or just 67 per cent of the estimated cost of doing the same work with a rig.**

These cost comparisons are actual job costs, whereas the costs for doing the same work conventionally are estimates based on jobs with no abnormal difficulties.

Sufficient wireline workovers have been performed at this date to present some examples of wireline workover costs. In one instance, a 9900-ft gas well was plugged to a higher sand at a total cost of $1600. Several wells in Galveston Bay have been recompleted at costs ranging from $1900 to $2500, and one wireline workover on a Bay well was accomplished for less than $1700. Single-string dually completed wells in the 5000- to 6000-ft range located on land have been worked over for $2100 to $2800, while a parallel-string dually completed well in the 9000-ft range located in inland waters has been reworked for $6000. Complete workovers, involving sand washing, several cement jobs and perforating, on inland water wells below 12,000 ft in depth have cost from $6900 to $15,000. These costs include the removal of drilling mud as well as the rental costs of barges, boats, tugs, and other marine transportation.

History of Wireline Workovers

The forerunners of the wireline workover was the initial use of a through-the-tubing perforator in November, 1950. The tubing-type perforator has constantly been improved since that date until the present tool of this type is equal to or superior to the conventional casing perforator used in 5½-in. casing. *The higher production rates obtained when perforating with salt water as a completion fluid and the safety and economy associated with this perforator have made the through-tubing-type completion conventional in the Gulf Coast areas where this type perforator is used several thousand times each year.*

A complete workover was performed on a well without the use of a rig in the spring of 1952. The successful field use of this new concept of testing and reworking wells indicated the possibility of a sizeable reduction in cost. Also, it made economically possible the more extensive testing of all producing intervals. Although only 33 wireline workovers were performed in 1953, over 500 workovers of this type will be performed in 1956.

At the same time, the elimination of perforation plugging and the use of nonplugging workover fluids (possible with the wireline workover) have permitted an entirely new concept of squeeze-cementing. Extensive testing of cements and cementing techniques with sandstone cores has given an insight into the role of filtration during the act of squeeze-cementing, and from this extensive testing has evolved the low-pressure squeeze-cementing theory and the application of low-water-loss cement.

Approximately 3000 wells in the sandstone producing areas of the Gulf Coast of Texas and Louisiana have been completed with the tubing above a number of producing intervals to permit future recompletions without a rig. To date, the permanent-type well completion technique has been used to complete and recomplete dual and single wells on land and water locations at a substantial cost saving.

Techniques and equipment have been developed that permit perforating, cementing, removal of sand and set cement, stimulation, and sand exclusion below the tubing without removing the tubing. These techniques have been used in straight and deviated wells to depths of 13,000 ft.

Several dozen abnormal pressure wells have been recompleted without killing the wells with mud. These wells have been reworked with surface pressure during the workover operations with greater safety and at greatly reduced costs. A large number of dual completions have also been reworked without a rig; and on certain types of dual completions, it has been possible to allow the upper zone to continue flowing while reworking the lower zone.

The utilization of through-tubing tools that permit wireline workovers has stimulated work on other tools that may be run on a wireline in producing wells such as flowmeters, leak detectors, and logging instruments. The use of smaller, lightweight tools and low pump pressures has made practical the use of smaller servicing equipment and many service com-

The Authors

Gilbert H. Tausch has been with Humble Oil & Refining Company since 1947 when he graduated from Rice Institute with a B. S. degree in mechanical engineering. From 1947 to 1950 he worked in the field serving as a roustabout and rotary helper, and this indoctrination was followed by engineering work on production and drilling operations. In 1950 he was transferred to Houston office to work on development of well completion techniques.

Price McDonald has been with Humble Oil & Refining Company since 1952. After completing Humble's engineering training program he entered production work as an engineer. For the last two years he has worked on well completion development problems. He graduated from the University of Oklahoma with a B.S. in mechanical engineering in 1949 and spent three years working with Halliburton Oil Well Cementing Company.

panies have unified this equipment to reduce the size and expense of the service equipment as well as to reduce the quantity of personnel necessary for operation of this equipment.

WELL INSTALLATIONS

The ideal time to equip a well for permanent completion work is during the initial completion; however, many existing wells may be economically equipped during any routine well servicing or recompletion operations. For those existing wells which have not been completed with equipment that can be utilized for permanent completion operations, it will be necessary to pull tubing to install the additional equipment in the tubing string. With the tubing string properly equipped, workovers of most wells can be accomplished with the tubing and wellhead installed.

General Tubing Requirements

In order to rework any type of well with wireline tools, the following specific tubing requirements must be considered:

1. Tubing string should be open ended and essentially full opening. The outside diameter of the wireline tools and through-tubing perforator necessary for a wireline workover permits only slight restrictions in the internal diameter of the tubing string. The internal diameter of the landing nipples used to seat the tubing extension hanger generally determines the maximum diameter of the various tools employed. As many as five selective landing nipples may be used in the same tubing string, whereas only one interference-type landing nipple is usually installed per string. When tubing is run, a gauge of tubing drift diameter, approximately 4 ft long, should be drifted through each joint to assure that only full-opening tubing is run. Joints which appear to have been damaged by tools or wrenches during makeup should be redrifted before running.

2. Bottom of tubing should be positioned above all desirable completion intervals. For convenience, wells are generally completed so that 1000 ft or less of extension pipe is required with a wireline workover; however, 1500 ft of 1-in. aluminum extension pipe has been run and retrieved successfully on a wireline. When a large number of potential producing intervals are present in a well, the anticipated producing life of these zones may determine the number of zones left uncovered below the tubing. Anticipated future tubing replacement because of corrosion or other trouble may permit the tubing to be suspended above only those zones to be produced prior to this tubing replacement, at which time the tubing may be reset at a higher point in the well. Under certain well conditions, such as limited number of zones, extreme well depth, or inaccessible locations, it may be desirable to leave 1800 to 2000 ft of cased hole below the bottom of the initial tubing installation.

The upper most productive interval should be at least 20 ft below the tubing bottom because of the possibility of rupturing the tubing or gas-lift equipment when perforating for production. For an initial well completion, it is desirable to leave at least two casing collars exposed below the tubing for depth correlation purposes.

3. Circulation means between tubing and casing annulus must be provided. In wells equipped with tubing packers, retrievable gas-lift valve mandrels, circulating sleeves, and side-port nipples may be used as circulating means since all three devices may be opened and closed at the operator's discretion. The valve mandrel is most frequently used because of anticipated future use as a corrosion inhibitor valve mandrel, while the side-port nipple is rarely used since it does not permit pressure-tight tubing while perforating.

4. Tubing string and wellhead must be pressure tight.

Specific Tubing Requirements

The type of permanent completion installation will vary with well characteristics. To help in fulfilling tubing requirements, the various installations are listed as follows with specific comments on wireline equipment. An illustration of each type of installation is shown in Fig. 1 and Fig. 2.

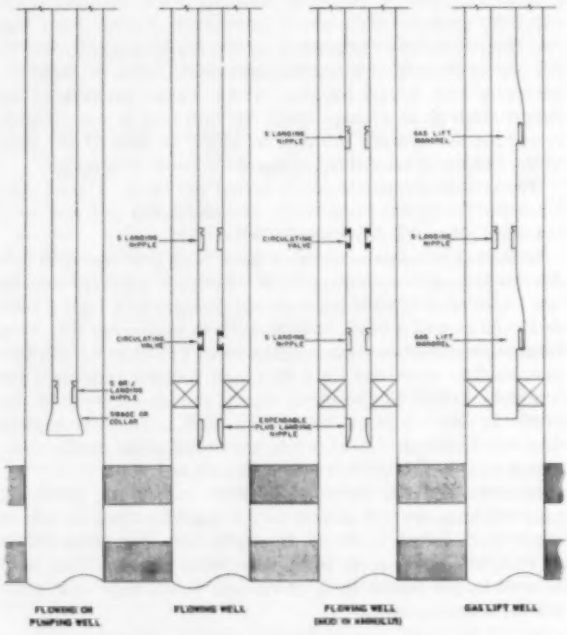


FIG. 1. **Single permanent type completions.** The well at the left has no packers; the only down-the-hole equipment is landing nipple and swage. The second well has a packer with a wireline-operated circulating valve installed between the landing nipple and the packer in order to provide communication between tubing and casing annulus during workover operations. Normally salt water with corrosion inhibitor is left in annulus. The third well has equipment for mud-packed annulus. The lower landing nipple provides a receptacle for plug to prevent mud from entering completion interval while mud is being displaced with salt water. The well at right is completed for gas lift.

Performance-Proved

There's a Lone Star Cement for Every Oil Field Job

Cement plays an important part in successful oil-well completion and long-term operation. Much depends on selecting the *right* cement for the job—considering depth, temperature, pressure or pipe corrosion.

On performance, and there's no better guide, the Oil Man *knows* that, when he pumps a Lone Star Cement down the hole, he is *sure* of the utmost in performance and protection.

This holds true for shallow holes and for the deepest wells yet drilled, for sulphate-water conditions, for casings, squeeze jobs, plug backs and restoring lost circulation.

Select the LONE STAR Cement that fits your job—all four cements are performance-proved, continuously laboratory-tested too, backed by an organization which never stops trying to keep pace with Oil Industry progress.

LONE STAR CEMENT CORPORATION

Offices: DALLAS • HOUSTON • ABILENE, TEX. • NEW ORLEANS • KANSAS CITY, MO. • BIRMINGHAM • ALBANY, N. Y. BETHLEHEM, PA. • BOSTON • CHICAGO • INDIANAPOLIS • NEW YORK • NORFOLK • RICHMOND • WASHINGTON, D. C.

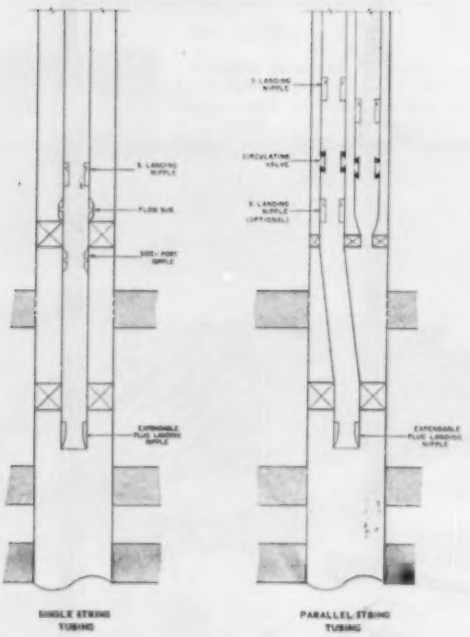


FIG. 2. **Dual permanent installations.** At left, the well is dually completed through a single string of tubing and the casing. The upper zone cannot be re-worked, and both zones are produced through the tubing simultaneously. Gas lift equipment can be installed. At right, the well is dually completed with parallel tubing strings. If mud is left in the annulus, the tubing to the lower zone should have two landing nipples. Production from both strings can be gas-lifted.

1. Wells Without Packers. Only a landing nipple is necessary for the wireline workover, and this nipple provides a recess for locking and a polished surface for sealing the tubing extension pipe hanger. The landing nipple should be installed near the bottom of the tubing string in order to minimize the amount of extension pipe needed for recompletions. A full-opening swage or collar should be placed on the lower end of the tubing to facilitate re-entry with wireline tools.

2. Wells With Packers. The essential requirements of a tubing packer in a well installed for permanent completion are that it be full opening, set with little weight, and hold substantial pressure differential from either direction. A wireline-operated circulating device must be installed between the landing nipple and the packer in order to have communication between the tubing and casing annulus during workover operations.

To prevent complications in wireline depth measurements and wireline operations, the circulating device is usually placed one tubing joint above the packer and one tubing joint below the landing nipple. Normally, salt water containing a corrosion inhibitor is left in the casing annulus of a flowing well. If mud is to be left in the annulus, and additional landing nipple should be spaced between the packer and circulating device. The lower landing nipple will serve as a receptacle for a tubing plug to prevent drilling mud from entering the completion interval while the mud is being displaced with salt water. When leaving mud in the casing annulus, extreme care should be exercised in the mud treatment to prevent settling of the mud solids or gellation of the mud.

If future abnormal pressure completions are anticipated, it is usually desirable to equip the lower end of a packer with an expendable plug landing nipple which serves to replace the swage or collar previously recommended. This nipple has a smooth inner surface for sealing and expendable plug set in the nipple by a wireline to permit running the extension pipe without well surface pressure.

3. Gas-Lift Wells. Both the offset- and concentric-type mandrels may be used for permanently completed wells and must be pressure tight during workover operations and must be capable of passing wireline tools when sealed. Gas-lift mandrels are often run on initial completion when it is anticipated that gas lifting will be required in the future; but it is sometimes not desirable to run the gas-lift valve until it is determined that the well will not flow. In gas-lift wells that produce sand, it is usually not advisable to install gas-lift valves in any mandrels below the working fluid level of the well.

4. Pumping Wells. In rod pumping wells, a 1 25/32-in. or 2¼-in. ID landing nipple for 2- or 2½-in. tubing, respectively, is used for seating the extension hanger and the rod pump. This interference-type landing nipple may be used with a cup-type pump hold-down; however, only one landing nipple may be run per string. If the pump is to be set high, two or more selective-type nipples may be employed with the lower one for permanent completion work. A special pump hold-down with selective keys may be used with the selective nipple.

In wells equipped for hydraulic pumping, the selective landing nipple is located above the pump seal nipples and is used only to suspend the extension pipe. Free-type pump installations are particularly adaptable to permanent completion work since the pump may be retrieved by circulation prior to the workover, and a well servicing unit is not required for any phase of the operations.

5. Dually Completed Wells. Two basic types of dual completions have been set up to permit wireline workovers of the lower zone only. With these installations, it is customary to perforate the upper interval prior to running the tubing.

a. Single-string tubing — tubing and casing annulus flow, Fig. 2. To permit sealing the upper zone during workover operations, it is necessary to use two full-opening tubing packers, one between the zones and another above the top zone. Since only the lower zone can be reworked, the bottom packer should be placed above as many productive intervals as possible. Equipment necessary in the tubing for a single-tubing permanent-type dual completion in addition to the two packers includes (1) a side-port nipple (a perforated nipple with a polished bore of landing nipple dimensions) immediately below the top packer for entry of the top zone fluid into the tubing, (2) a flow sub (a short perforated nipple) immediately above the top packer for passage of fluids from the tubing to the casing annulus, and (3) the landing nipple which is mounted on top of the flow sub. By installing the necessary nipples adjacent to the upper packer, the retrievable flow choke length may be shortened to its minimum length.

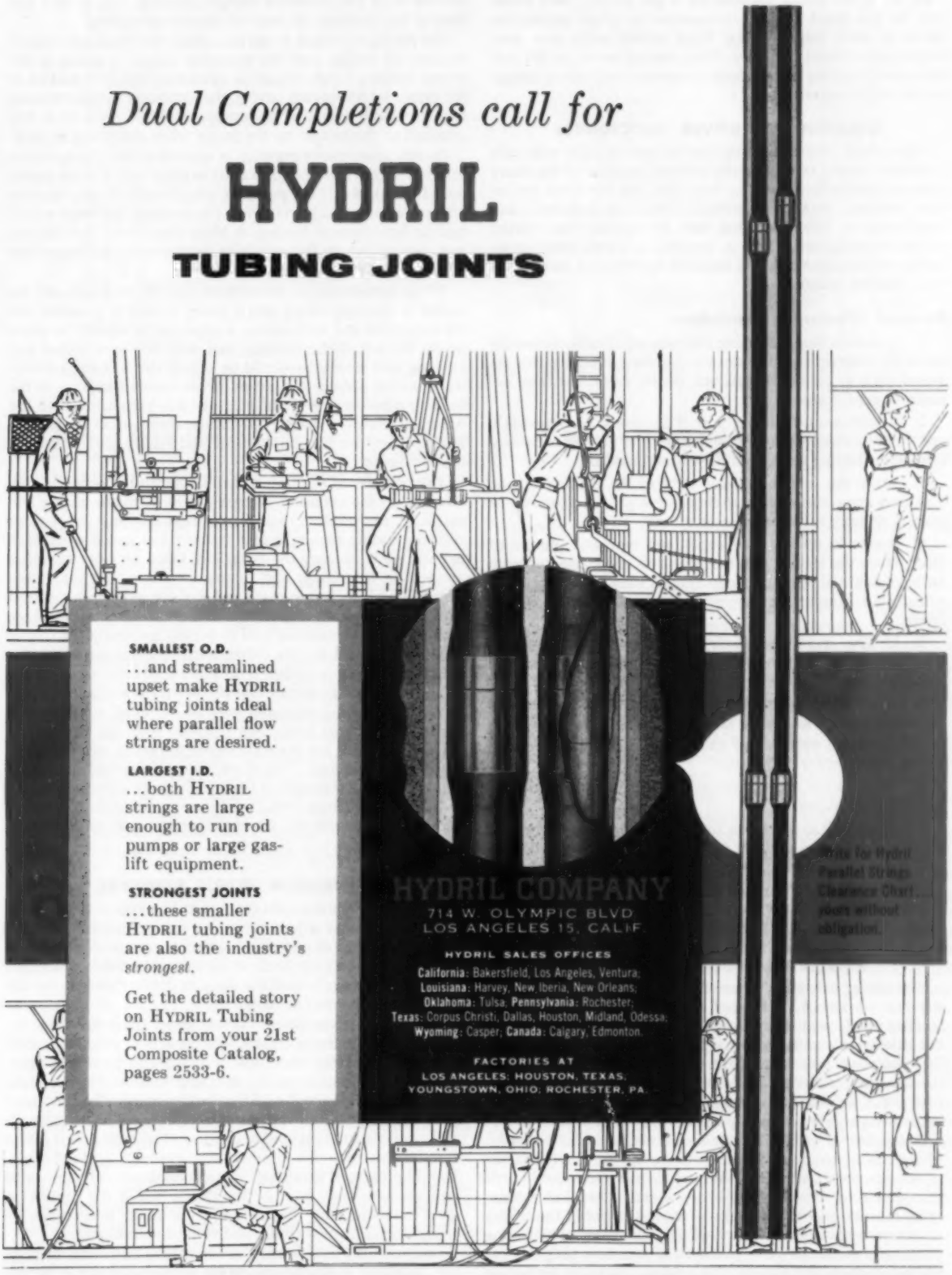
With single-tubing installations, artificial lift of both zones may be accomplished with the installation of retrievable gas-lift valve mandrels and small pipe. This single-tubing type of dual installation is very economical but is limited in its application to zones producing relatively sandfree and noncorrosive fluids and to pressures that can be permitted in the casing annulus.

b. Parallel-string tubing — tubing flow, Fig. 2. Two packers are also necessary in this second basic permanent-type dual completion setup to facilitate reworking the lower zone. If the flow paths from the two zones are completely separated by the packers and tubing strings, the lower zone tubing string is equipped like a single completion with one landing nipple and a circulating port. If mud is to be left in the casing annulus, two landing nipples are desirable in the lower zone tubing string. A landing nipple and circulating port are generally installed in the upper zone tubing string also to permit

Dual Completions call for

HYDRIL

TUBING JOINTS



SMALLEST O.D.
...and streamlined upset make HYDRIL tubing joints ideal where parallel flow strings are desired.

LARGEST I.D.
...both HYDRIL strings are large enough to run rod pumps or large gas-lift equipment.

STRONGEST JOINTS
...these smaller HYDRIL tubing joints are also the industry's *strongest*.

Get the detailed story on HYDRIL Tubing Joints from your 21st Composite Catalog, pages 2533-6.

HYDRIL COMPANY
714 W. OLYMPIC BLVD
LOS ANGELES 15, CALIF.

HYDRIL SALES OFFICES
California: Bakersfield, Los Angeles, Ventura; **Louisiana**: Harvey, New Iberia, New Orleans; **Oklahoma**: Tulsa. **Pennsylvania**: Rochester; **Texas**: Corpus Christi, Dallas, Houston, Midland, Odessa; **Wyoming**: Casper; **Canada**: Calgary, Edmonton.

FACTORIES AT
LOS ANGELES; HOUSTON, TEXAS; YOUNGSTOWN, OHIO; ROCHESTER, PA.

Write for Hydril Parallel Strings Clearance Chart... yours without obligation.

DRILL PIPE...CASING...OR TUBING...YOUR BEST CONNECTION IS HYDRIL

sand washing operations in that zone.

By using the casing annulus for a gas supply, both zones may be gas lifted through concentric or offset retrievable valves in each tubing string. Dual tubing wells also may be pumped without difficulty. Many variations of gas lift and hydraulic pumping are available; however, both tubing strings can be run simultaneously.

WIRELINE WORKOVER PROCEDURES

The orderly step-by-step method of reworking a well with a wireline cannot be specifically outlined because of the many types of completions encountered. Also, the workover procedure will vary because of individual well characteristics and conditions or difficulties that may be encountered during workover operations. There is, however, a logical order or sequence of operations that is required to rework a well in the most efficient manner.

General Workover Procedure

1. Ascertain that the tubing will pass wireline tools and remove all obstructions that do not require circulation for removal such as chokes, regulators, tubing stops, etc., and occasional sand bridges.

2. Establish a circulating port if necessary and provide a salt water or clean workover fluid system. It may be necessary to remove drilling mud from the casing annulus.

3. Make the tubing pressure tight to the landing nipple. This may consist of closing sliding-sleeve gas-lift mandrels or placing dummy valves in offset mandrels.

4. Ascertain present well depth, and type and amount of fillup. Once the locator tool has been run and compared with an available casing-tubing collar log, it may be necessary to run a bailer, sampler, or impression block to determine type of fillup.

5. If fillup must be removed, run the proper tubing extension, pressure test, and perform the operations necessary to remove fillup.

6. Use tubing extension for cementing operation and test the cement job if necessary after the proper time interval.

7. Ascertain presence of excess cement or node buildup to determine future operations.

8. Remove the excess cement if too high or reduce node buildup if excessive.

9. Place well in condition for perforating by placement of corrosion inhibitor solution in the casing annulus if desired and light fluid in the tubing or reinstall gas-lift valves if necessary.

10. Perforate the well for production. Unload or artificially lift wells that will not flow.

RETRIEVABLE TUBING PROCEDURE

The tubing extension is one of the major tools employed in wireline workovers. It is used to direct fluid from above a landing nipple near the bottom of the tubing to a point below the tubing — usually in the vicinity of casing perforations. The extension pipe is used for operations such as debris removal, sand removal, acidizing, and squeeze-cementing. A tool called an "extension hanger" is used to seal in the tubing landing nipple and to suspend the extension pipe.

A number of auxiliary tools are sometimes used as a part of the tubing extension such as *telescoping joints, plug cutter* or *reverse check, acidizing bits,* and the *very commonly used pumpout plug.* The pumpout plug is merely a small aluminum plug that fits into a receptacle on the lower end of the tubing extension and seals the bore of the extension with O-ring packing to permit pressure testing. The pumpout plug is shear pinned in place and may be blown from the end of the tubing by applying pressure on the inside of the extension. When telescoping joints or the cement plug cutter and reverse check are used in the extension string, and O-ring seal prong is utilized with the extension hanger running tool to seal the bore of the extension in place of the pumpout plug.

The tubing extension is run on a small wireline and lowered through the tubing until the extension hanger is seated in the proper landing nipple. Once the extension hanger is locked in the nipple by downward jarring, the extension hanger running tool may be retrieved if the pumpout plug is used or is left attached to the hanger by the prong when the prong is used.

At this time, pump pressure is applied to the casing to ascertain that the extension is locked in place and will not pump out of the nipple. If the pumpout plug is used, it may now be released by upward jarring after the pressure has been equalized in the extension hanger. A blind box should then be run and used to tap on the extension hanger after the prong has been retrieved.

When concentric- or sleeve-type gas-lift mandrels are installed in the well tubing and a prong is used to pressure test the extension and well tubing, a rope socket should be made up on the top of the running tool, and this rope socket and running tool assembly should be run in the well on a downward jarring pulling tool. After the extension hanger is in the landing nipple and a slight pressure has been applied to the tubing, downward jarring will cut the shear pin in the pulling tool and between the running tool and fishing neck of the extension hanger.

This manner of running is used to permit the prong to stay attached to the extension hanger during pressure testing and still leave the wireline tools free so that they may be used to shift the sliding sleeves in case a sleeve has accidentally been opened while running the extension. Once pressure has been applied on the casing and tubing to assure that the extension hanger is locked in place and that the well tubing is pressure tight, a pulling tool may be run and latched on the rope socket above the running tool to permit retrieving the O-ring prong by upward jarring. After retrieving this assembly, the extension hanger is tapped with a blind box before using the tubing extension to assure that the hanger is locked.

When the tubing extension must be retrieved, a pulling tool is run with a short prong that partially seals the bore of the extension hanger but does not cover the small relief holes in the extension hanger. The short prong is selected because it will prevent the pulling tool from latching on valves contained in offset gas-lift mandrels if they are installed in the tubing and will also permit the use of the pump as an aid in retrieving the extension.

ALUMINUM DEBRIS REMOVAL

Aluminum debris results from poor breakup of tubing guns or from extension pipe dropped or inadvertently left in the tubing or casing of a well. If sufficient cased hole is below the intended working level to contain gun debris, an effort should first be made to drive the gun debris down to the desired level with wireline tools.

When the debris cannot be removed from the intended working level in the casing by wireline action, it is then necessary to dissolve the aluminum with an acid or caustic soda solution. The latter is usually desirable because it is more economical, can be mixed with cementing pumps, has no effect on cemented perforations, and is safer to handle. The strength of the caustic solution used to dissolve aluminum debris is also more potent than the commercially available acid solutions. The solution used for dissolving the aluminum debris must be brought in contact with all the debris and if the solution is spent following the reaction, fresh solution must again be brought in contact with the undissolved aluminum.

Steel or iron pipe is used as the tubing extension in placing caustic or acid solutions. If the extension pipe can be run beside the aluminum debris such as the case of an aluminum tubing extension, the steel pipe should be run to the lowest

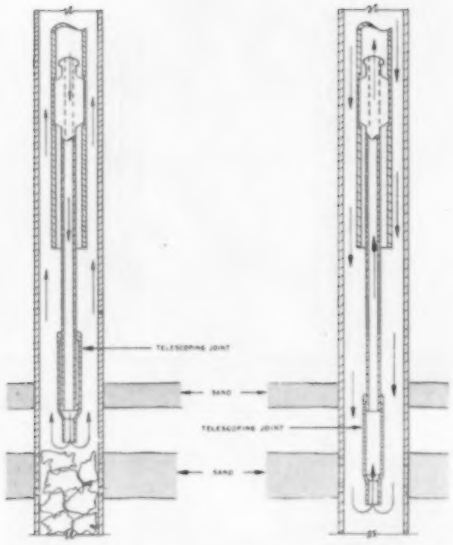


FIG. 3. **Gun debris removal.** The steel telescoping joint expands in length as the aluminum debris from the tubing gun is dissolved by caustic and circulated up the annulus.

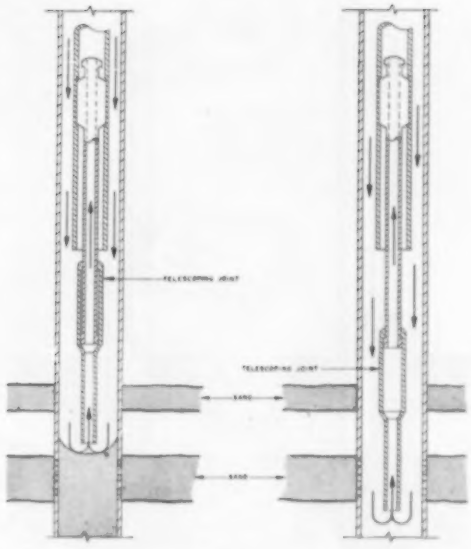


FIG. 4. **Sand removal.** Aluminum telescoping joint follows the top of the sand as it is reverse circulated out of the well.

depth that it is desired to spot the solution and remove the aluminum debris. When it is not possible to run the extension alongside the debris, steel telescoping joints are used to allow the extension to expand in length as the aluminum debris is dissolved. The length of the extension is then calculated to extend from the debris to the landing nipple when the telescoping points are collapsed.

The telescoping joints should be placed on the bottom of the extension or within one joint of the bottom of the extension as shown in Fig. 3, since the circulation pressures tend to expand the telescoping joints and may kink or bend the steel pipe below the telescoping joints if an excessive length is used. The steel tubing extension is suspended from the conventional extension hanger seated in the landing nipple above the open circulation port. A circulation path must be established prior to running the extension, and a prong should be used in the extension hanger running tool to permit pressure testing the tubing and hanger after seating and locking in the landing nipple.

One pound of caustic soda will dissolve approximately 0.7 pound of aluminum; however, because of inaccuracies in placement and dilution by well fluids, a large excess of dissolving solution is generally used. Caustic soda is normally mixed in concentrations of 75 to 100 lb per barrel of water. Normally, 4 to 10 bbl of caustic solution are batch mixed according to the amount of aluminum to be removed and to the length of casing interval containing aluminum that must be filled with this solution. The caustic solution should be displaced through the iron extension until approximately ½ bbl of solution is around the end of the extension. At this time, the pumping rate is greatly reduced and the additional solution should then be pumped around the extension to completely displace the dissolving solution from the extension in approximately 2 hours.

After sufficient time has been allowed to permit the caustic or acid solution to dissolve the aluminum debris, the spent solution should be circulated to the surface. The spent solution will be very gaseous because of hydrogen gas formed as a reaction product and some kind of adjustable choke or valve should be provided at the surface to prevent too rapid expansion of this gas. Steel line should always be used to conduct the spent solution and gas from the well to the disposal pit or tank.

SAND REMOVAL

It is often necessary to remove produced sand from either the tubing or casing to permit the completion of workover operations or to restore production. The method of removing the sand depends upon the position of the top of the sand within the well bore and the type of well installation. On most occasions, aluminum tubing extensions and telescoping joints are utilized with a surface pump to permit reverse circulation of the sand from the well. When the tubing extension cannot be used because of the location of the sand or the type of well installation, small-diameter bailers or sand pumps are run on a wireline and permit a small portion of the sand to be removed with each trip of the bailer in the well.

When a tubing extension may be utilized to remove produced sand, this extension is composed of 1-in aluminum pipe and telescoping joints also made of aluminum. These telescoping joints are composed of two sections of aluminum pipe which slide past each other permitting the joints to expand and collapse. With the lower end of the tubing extension resting on the sand, the telescoping joints will extend in length as sand is removed from the well, permitting the tubing extension to remain in contact with the top of the sand as shown in Fig. 4.

To prevent the extension pipe from sinking too deeply into the sand, thereby plugging and preventing circulation, a collar is placed on the bottom of the pipe. The telescoping joints are placed approximately 100 to 200 ft from the lower end of the extension. The weight of the extension below the joints is sufficient to extend the telescoping joints and yet does not allow excessive weight on the end of the extension against the top of the sand. Generally, a maximum of 60 ft of collapsed telescoping joints is used for sand washing operations since an excessive quantity of joints may not provide sufficient rigidity to permit easy telescoping action. Tapered shoulders should be provided on the outer section of the telescoping joints to facilitate re-entry into the tubing.

When all of the sand is not removed from the well with one trip of the tubing extension, the extension may be pulled to the surface and additional extension pipe may be added

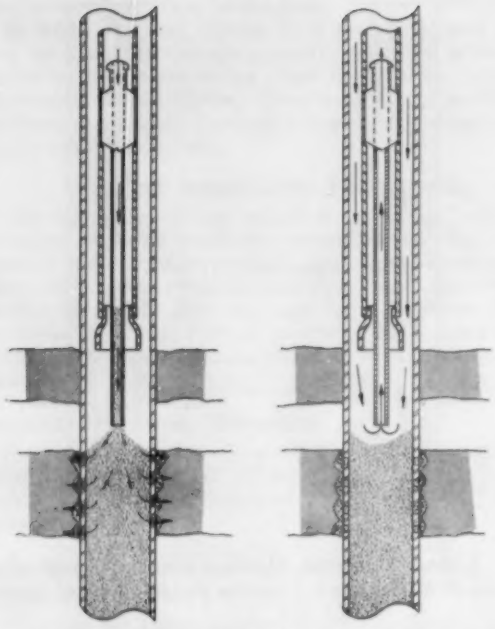


FIG. 5. **Plugback cementing.** When a zone is to be permanently abandoned, the cement slurry is spotted opposite the perforations; excess cement is reversed out through the tubing.

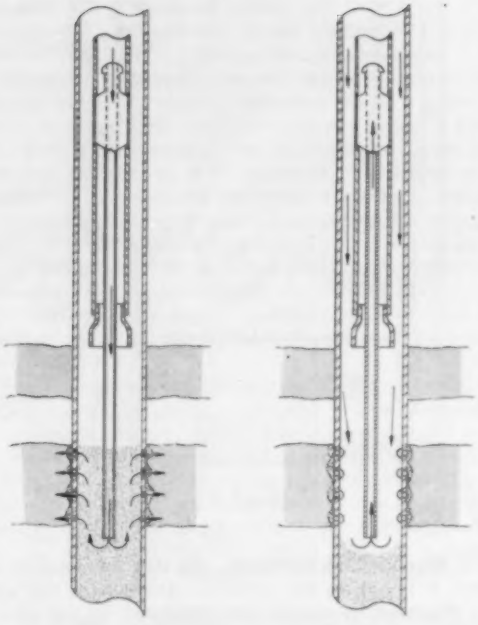


FIG. 6. **Set-through squeeze cementing** permits completions in lower zones. After squeezing, the excess cement is reversed out through the tubing.

below the extension hanger. The length of the extension pipe added must be less than the footage of the sand removed and in all cases must be less than the collapsing distance of the telescoping joints.

Once the tubing extension is in position with the telescoping joints collapsed, circulation is commenced down the casing to remove sand up the tubing extension and well tubing. Once the circulation is commenced, it must be continued until a volume of circulation fluid somewhat greater than the well tubing volume has been circulated from the well to assure that the sand is removed from the tubing and will not settle or bridge in the tubing when the pumping action is stopped. If circulation is partially or completely lost as sand is removed from the interval opposite the perforations, and there is insufficient circulation to bring the sand to the surface, circulation down the tubing should be commenced to squeeze the sand through the perforations into the cavity behind the casing.

When gun debris has become surrounded by sand and prevents the tubing extension from lowering in the well bore as sand is removed, a combination of sand washing and debris removal operations must be used. Steel or iron extension pipe and telescoping joints are used and an attempt is made to remove sand by reverse circulation. When the extension is finally stopped by debris, several barrels of workover fluid is pumped down the tubing and the sand jetted from below the extension is then removed by reverse circulation. At this time, a caustic soda or acid solution may be spotted around the end of the extension to dissolve the aluminum debris. The operation of reverse circulation and spotting caustic solution is alternated until all the aluminum debris and sand are removed from the well.

WIRELINE SQUEEZE-CEMENTING

Low-pressure squeeze-cement jobs are divided into plugback jobs and set-through cement jobs. Plugback jobs, Fig. 5, leave cement slurry in the casing opposite the perforations and are used when a zone is permanently abandoned and the well is to be completed in a higher zone. Set-through squeeze-cementing, Fig. 6, leaves the well bore open through the previously perforated interval and permits reperforating all or a portion of the old interval as well as permitting completions in a lower zone. The same basic method of squeeze-cementing is used with both plugback and set-through jobs.

Once the well depth measurements have been determined by using the wireline locator tool and collar log, the 1-in aluminum pipe is measured at the surface and made up in the desired length for cementing operations. When the extension hanger is seated in the landing nipple, the lower end of the extension is positioned at the point in the liner or casing to which the well must be left free of cement.

When it is impossible to squeeze salt water or other workover fluids into the formation without fracturing the formation or when a large amount of cased hole is left below the perforations, a plug cutter and reverse check are used with the tubing extension, as shown in Fig. 7, as a means of spotting a displacement-type plug in a well. The reverse check is placed on the bottom of the extension and generally run 5 to 10 ft above the bottom of the hole and the plug cutter is placed in the extension at the point to which it is desirable to leave the top of the cement plug.

For low-pressure squeeze-cementing operations, 12 per cent bentonitic cement (modified cement) is generally selected for plugback jobs because of the higher initial strength which permits faster operations with less waiting-on-cement time. Twenty-five per cent bentonitic cement (modified cement) is generally selected for set-through jobs where the well bore must be left open through the previously perforated interval because the filtration rate of this cement is much lower and therefore prevents excessive cement node buildup that would tend to restrict the internal diameter of the casing or liner. The higher filtration rate of 12 per cent bentonitic cement results in more node buildup but does not prevent retrieving the tail pipe below the plug cutter.

Since low-pressure squeeze-cement jobs are performed by the bradenhead method and place the full squeeze pressure

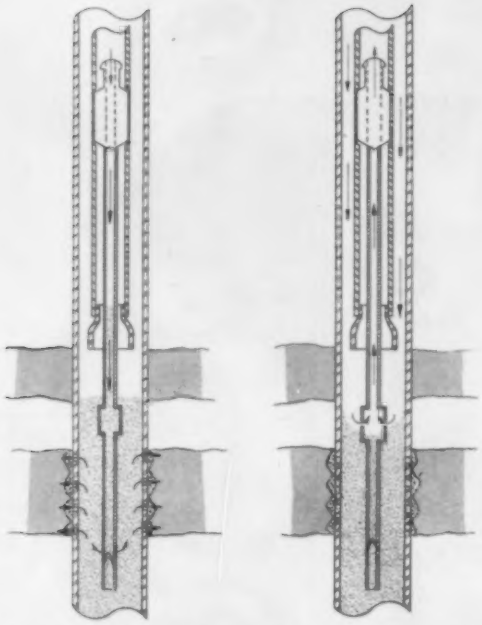


FIG. 7. **Plug cutter and reverse check** is used to spot displacement-type plug in a well. The reverse check is usually run 5 to 10 ft above the bottom of the hole and the plug cutter is placed in the extension at the desired height of the plug.

on the casing, the desired pressure rating of the casing is the first requirement in limiting the squeeze pressure. A squeeze pressure is generally selected that will be 300 to 500 psi greater than the anticipated reverse circulating pressure to prevent accidentally fracturing the formation with excessive reverse circulating pressure. Squeeze pressures have varied from 400 psi to 2500 psi with no apparent effect on the success of the squeeze job. Fifteen hundred to eighteen hundred psi squeeze pressure is generally used.

The quantity of cement slurry generally ranges from 8 to 15 bbl. It is preferable not to use excessive amounts of cement slurry when a lesser amount will provide sufficient cement for the job. The smaller quantities are preferable because of lower reversing pressures. However, sufficient cement must be mixed to allow some cement to be in the extension when the job is complete if the cement is heavier in weight than the workover fluid. This is particularly true on a set-through job when the perforated interval is some distance above the bottom of the tubing extension.

Because of the small quantities of cement slurry used and the need for uniform slurries, the batch method of cement mixing with small tank mixers is preferred to hopper mixing. The necessary amount of mix water measured into the mixing tank, the correct quantity of retarder is then added to the mix water and stirred until a uniform solution is obtained, and the cement and bentonite are then added to this solution as it is being circulated through the cementing pump and tank jets. The cement and bentonite are added at the same time; however, extreme accuracy in adding these materials simultaneously is not necessary. Fresh water should always be selected for mix water, and a good grade of Wyoming bentonite, free of peptizing agents, should be used in mixing modified cement. The amounts of retarder necessary for modified cement containing 12 or 25 per cent bentonite are shown in Fig. 8 or Fig. 9.

After all ingredients have been mixed and the cement slurry

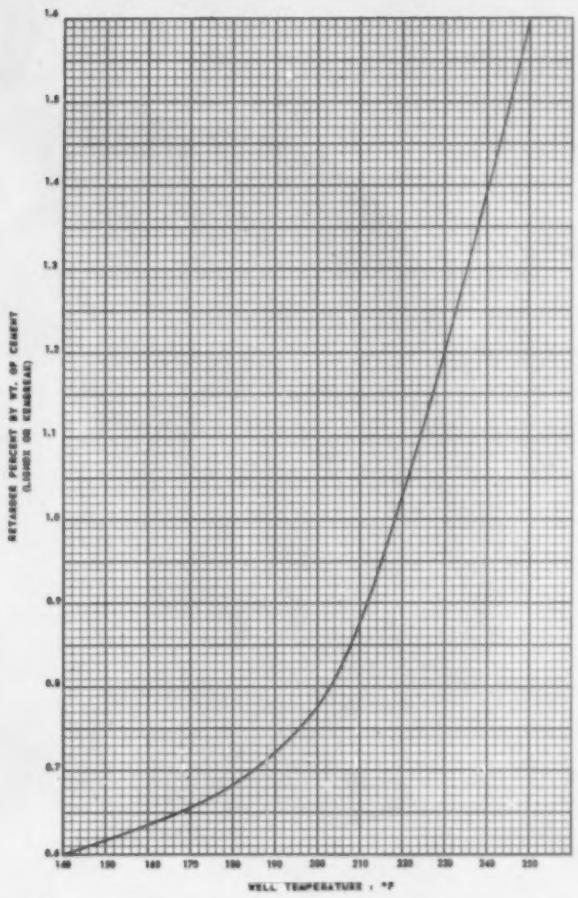


FIG. 8. **Retarder necessary** for cement containing 12 per cent bentonite.

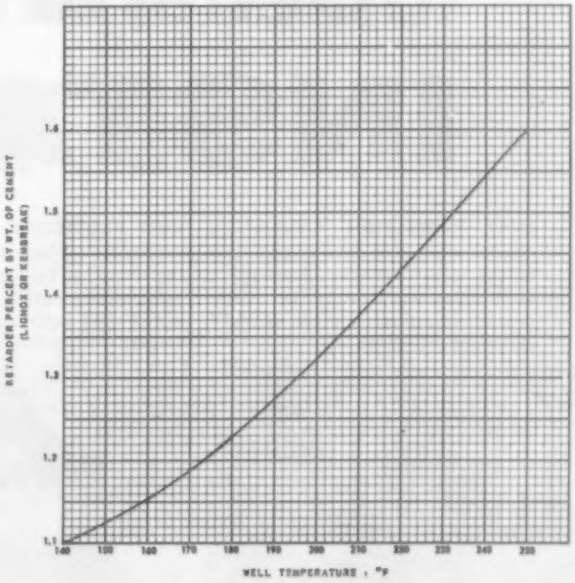
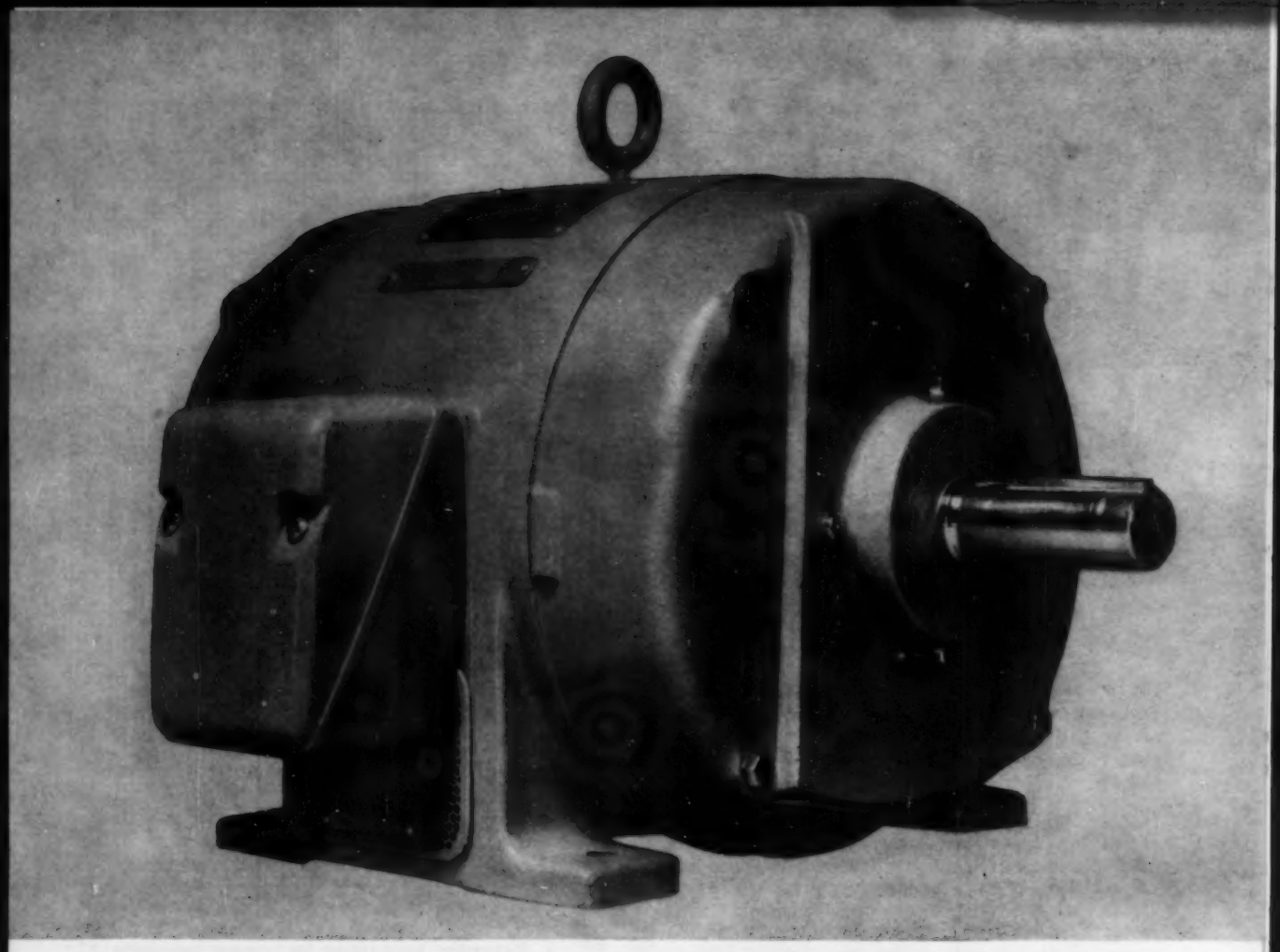


FIG. 9. **Retarder necessary** for cement containing 25 per cent bentonite.



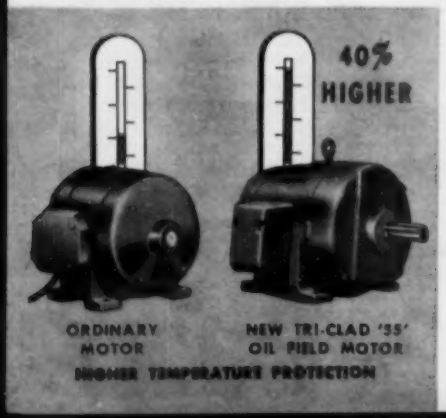
General Electric's NEW

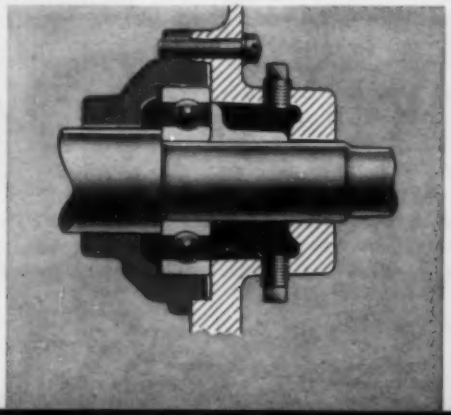
INSTALL IT...

HEAT PROTECTION—Alkanex*, a revolutionary new wire enamel used in the field windings, allows up to 40% higher temperature rise than is possible in ordinary motors, virtually eliminates burnouts.

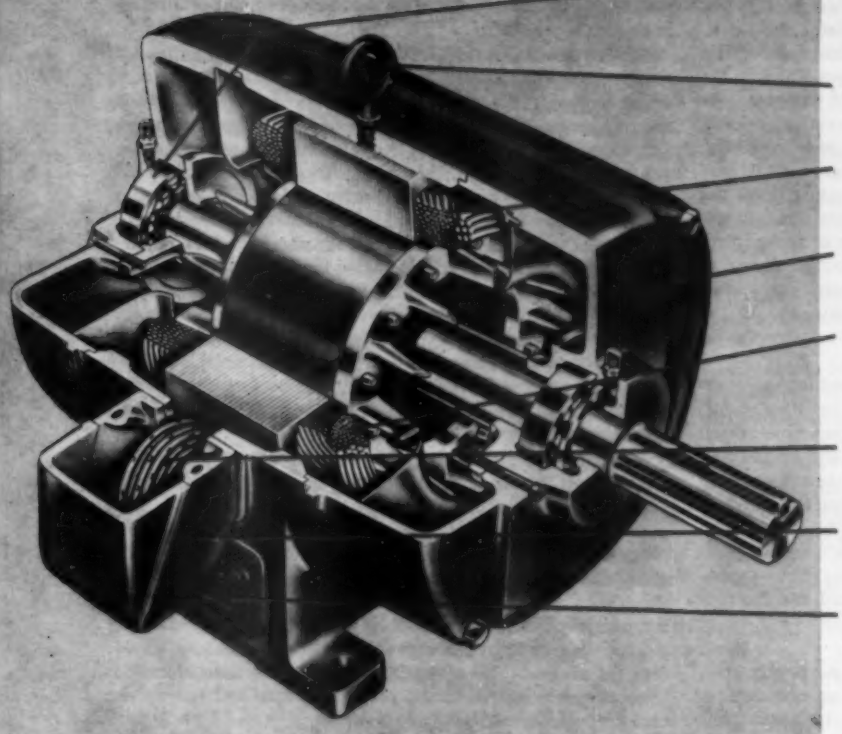
DUST PROTECTION—Closely machined bearing caps and housing on each side of bearings, plus the new G-E Tri-Clad "55" oil field motor's low velocity air intake system, keep dirt and dust out of vital parts, help give added protection for longer, trouble-free operation.

MOISTURE PROTECTION—Field windings, coated with water-shedding silicone Dri-Film*, plus cast-iron frame construction and close fits between all joining surfaces, help prevent motor failure due to moisture.





PACKED WITH MONEY-SAVING FEATURES



1. Advanced bearing system will last longer without regreasing than any other motor bearing system.

2. Convenient eyebolt cuts installation time, —permits easier handling.

3. Water-shedding stator windings virtually eliminate breakdown due to moisture.

4. Rugged cast-iron frame helps prevent corrosion and accidental damage.

5. Class 'B' insulation system with revolutionary Alkanex* wire enamel allows up to 40% higher temperature rise.

6. Perma-numbered leads are easy to read even when taped or clipped.

7. Easy-access conduit box is large and roomy for fast wiring.

8. Removable screens protect motor against damage from rodents and rocks.

*Registered trade-mark of General Electric Company.

TRI 55 CLAD oil field motor

REG U.S. PAT. OFF.

FORGET IT!

General Electric's all-new Tri-Clad "55" oil field motor is specially designed and engineered for long, trouble-free operation on rugged, outdoor pumping applications.

This motor will run far longer without attention than ordinary motors because it is protected against heat, dust and moisture. Burnouts have been virtually eliminated by the use of Class 'B' insulation made from new "miracle" materials Alkanex, heat-resistant enamel wire, and Mylar† mica-glass laminate slot and phase insulation.

The high heat resistance of this new insulation means you get more horsepower per pound in a more compact, cast-iron frame, because it has been possible to reduce ventilation space. The large grease reservoir and revolutionary bearing system has reduced normal maintenance to a few minutes every five years. The eyebolt, large roomy conduit box and perma-numbered leads—"extras" at no extra cost—cut installation time to a minimum.

A new G-E oil field motor on your pumping rig is easily your most economical buy. Install it . . . forget it. For more information write for Bulletin GEA-6546 or contact your nearest General Electric Motor Distributor, or G-E Apparatus Sales Office. 877-1

†DuPont trade-mark

MEDIUM INDUCTION MOTOR DEPARTMENT

Schenectady 5, New York

Progress Is Our Most Important Product

GENERAL ELECTRIC

nas been circulated through the pump and tank for approximately 5 to 10 minutes, a sample of the cement slurry should be obtained and weighed on conventional mud scales. A 7½ minute filtration test of this cement slurry is then obtained in the standard API drilling mud filtration press at 100 psi. The color of the filtrate should be characteristic yellowish-brown color of the retarder; and the filtration rate of the cement slurry should be no greater than above 120 cc's for 12 per cent bentonitic cement or 90 cc's for 25 per cent bentonitic cement. The filtration rate of 12 per cent gel cement will vary from approximately 45 to 110 cc's in 30 minutes, API, while the filteration rate of 25 per cent-gel cement will likewise vary from 35 to 90 cc's, API, depending upon the quantity of retarder used. The surface filtration rate will decrease as more retarder is added to allow for increased well temperatures. If a high filtration rate is obtained or other surface tests indicate a possible improper cement slurry, this slurry should not be used but should be pumped onto the ground or to a pit and a new batch of cement slurry should be mixed.

Once the cement slurry is mixed, it is pumped into position in the well by pumping the cement down the tubing and following the slurry with the correct volume of workover fluid. The cement is displaced around the extension and up the well bore until it extends above the perforations or the cement plug cutter before the casing valve is closed. After the valve is closed and the squeeze pressure is increased, the cement will rise in the well bore around the tubing extension due to compression of fluids in the casing annulus and due to the expansion of the casing. Fluid is then slowly displaced into the tubing to squeeze cement against the formation and to dehydrate cement in any channels or perforations.

On no occasion should the formation be purposely fractured or broken down prior to or during the squeeze-cement job. Should the formation break down or fracture while squeezing, as indicated by a sudden decrease in squeeze pressure and an inability to build up pressure, the cementing pump should immediately be stopped; and after 2 or 3 minutes, fluid may then be pumped down the tubing at a very slow rate. After increasing the pressure several hundred pounds, the pump should again be stopped and this procedure repeated. By stopping the pump periodically, the cement is allowed to dehydrate in the fracture and thereby bridge the fracture and prevent its extension. If pumping is continued at a rapid rate after fracturing, modified cement may easily be pumped into the fracture faster than the cement can dehydrate against the formation. Once pressure is released, the fluid cement will then flow back into the well bore. By using the hesitation method of squeeze-cementing, it is possible to obtain a squeeze pressure above that of the fracturing pressure. Once the final squeeze pressure has been obtained, the cementing pump should be stopped and the pressure should be observed for 5 to 10 minutes. If this pressure remains steady and does not decrease, the squeeze job is complete.

Once the desired squeeze pressure is obtained, it is necessary to reverse out the excess cement still in the well. This is done by slowly opening the tubing valve while slowly pumping into the casing. By adjusting these rates, the casing pressure may be kept several hundred pounds lower than the final squeeze pressure while reverse circulating. One thousand psi is generally left on the wells after squeeze-cement jobs; however, a lower pressure will be used in the cases of very low squeeze pressures. In no case should pressure higher than reversing pressure be left on a well.

When squeeze-cementing wells having surface pressure with the extension in place, a choke must always be maintained on the return line while pumping into either the tubing or casing. The back pressure maintained by the choke must be greater than static surface pressure on the well. Squeeze pressure and reversing pressures for abnormal pressure wells are selected as with a normal pressure well, but are generally somewhat higher because of the necessary back pressure. It is often necessary to reverse circulate at a somewhat slower rate to reduce the circulation pressure on the casing because of the back pressure on the tubing.

When returns cannot be obtained while circulating the well, two pumps may be used, thus pumping fluid into the casing while cement and water are pumped down the tubing. Once the cement has filled the perforations, it will be possible to obtain returns and the well may be squeeze-cemented in the conventional fashion. Another method of squeeze-cementing this type of well is to displace the cement and correct volume of salt water down the tubing until several barrels of cement have contacted the perforations. The tubing valve is then closed and salt water is pumped into the casing until the casing is filled. Then salt water in again pumped into the tubing and the squeeze job performed in the conventional fashion. If the well container a packer and an offset-type gas-lift mandrel for a circulation port, a dummy valve containing a reverse check may be used in the circulation port that will permit reverse circulation through the mandrel but will not permit circulation from the tubing to casing.

When using 12 per cent-gel cement, it is generally preferable to wait 24 hours before testing the cement job. For 25 per cent bentonite cement, waiting-on-cement time is generally 36 hours. Years of experience have shown that testing plugback jobs is not necessary if the cement plug is found above the perforations. If the cement plug is found exactly at the top of the perforations, it may be advisable to test the squeeze job since node buildup in the perforations could give a false indication of the top of the plug when using 12 per cent-gel cement. This time allowed for waiting on cement is generally the time until the test pressure is exerted on the cement perforations.

When testing a set-through cement job, it is preferable to test by creating a pressure differential into the well. This is the only true indication that the cemented interval will not produce into the well while producing a new zone. This pressure differential should be at least as great as the pressure drawdown to be exhibited while producing the new interval.

SET CEMENT REMOVAL

It is necessary to remove set cement in order to deepen a well for further operations when a cement plug has been inadvertently placed too high in the well bore due to an error in measurement or when an abandoned zone covered with cement must be re-entered. To remove the cement plug located in the well bore below the circulation port, acid is utilized with the tubing extension to dissolve the cement and circulate the spent material from the well. The presence of excessive cement filter cake or node buildup opposite cemented perforations may prevent the passage of the tubing-type perforator or other wireline tools, and this type of set cement is generally removed with wireline by chipping action with special bits. Likewise, cement located in the tubing above the circulation port is removed utilizing a bit in combination with a bailer. This bailer with cutting head or bit is similar to but smaller than cable tool equipment.

Either ¾-in. or 1-in. diameter steel or iron tubing extension with telescoping joints is used to conduct wash acid or mud acid in contact with the set cement. Five hundred gallons of mud acid will remove approximately 25 to 30 ft of cement in 5½-in. casing, assuming full circulation. An acidizing bit, resembling a diamond point or small fish-tail drilling bit, is placed on the bottom of the steel extension. This bit contains two small drilled holes to allow jetting action with the dissolving acid. Steel telescoping joints are positioned on the lower end of the tubing extension and permit the extension to

extend in length as cement is removed from the well. The acid is pumped through the bit at a circulating pressure of about 1800 to 2000 psi and is then reverse circulated back into the tubing at a slower rate. This process is repeated four or five times until the cement has been removed or the acid is spent.

PERFORATING

Tubing-type perforators are now available that may be run through 1½-in. or larger tubing, and these guns are offered through a number of service companies. At the present time, all tubing guns utilize jet charges and the penetrating ability, debris characteristics, and performance of these guns are constantly being improved.

Although the use of these perforators is not confined to through-tubing work, they are utilized to their maximum advantage only when the perforating is performed in the presence of a nonplugging fluid and preferably with a pressure differential into the well bore. The use of conventional perforators restricts the use of nonplugging fluids and the presence of a pressure differential into the well bore. Conventional perforating in mud may leave many of the perforations filled with mud filter cake not readily removed by production and therefore does not utilize each perforation hole to the fullest productive capacity. Perforation plugging may aggravate sand production problems by creating a greater fluid withdrawal rate through each perforation hole remaining open and may also prevent hydrocarbon production from some portion of the formation when shale streaks or sand stringers are present in the formation.

All tubing guns may be acquired with a bottom-firing device on special request. The bottom firing of guns permits added assurance that the entire gun has detonated since the unfired upper portion of the gun will generally be retrieved with the collar locator and cable head should some malfunction occur. A small-diameter collar locator and cable head are run with each tubing gun to permit correlation of casing and liner collars to previously run logs. Collar locators and cable heads are now available in sizes as small as 1⅜-in. OD, and these small collar locators may be run with large diameter guns to permit easier passage through the tubing.

When running a tubing gun into a well against surface pressure or when it is anticipated that the collar locator and cable head must be withdrawn from the well after perforating in the presence of a high surface pressure, a flow tube stuffing box can be furnished by the service company and should be used in place to the conventional lubricator stuffing box. When perforating wells with higher surface pressures, the grease injector lubricator should be used.

SAND EXCLUSION

Although sand can be successfully removed from a well equipped for permanent completion without using a rig, the repeated need to remove sand becomes both troublesome and costly; and when excessive sand production occurs, it is necessary to take measures to stop formation sand production. Basically, the same methods of sand exclusion used with the conventional workover may be used with the permanent completion method of reworking wells. Sand exclusion processes used to date include both means of filtering, such as screens, gravel packs, and Sandlock, and the consolidation of formation sand in place. To effectively utilize filtering methods of preventing sand production, some knowledge of the particle size of the produced sand must be obtained. To successfully prevent sand production by some mechanical means, it is also imperative that the perforations not be covered or filled with mud filter cake since this cake will plug screens or filter beds and will prevent the injection of consolidation material into the formation sand.

Screens. Small slotted screens with blank liners can be run on a wireline and suspended from the landing nipple in the well tubing, thus forcing all well production through the screen. The small diameter of the screen and the long length of blank liner often required may limit the use of screens. Filtering with mechanical screens also has the inherent disadvantage of reducing well productivity through the produced sand in the well perforations and the produced sand bridged between the screen and casing wall.

Gravel Packing. When utilizing gravel packing for excluding sand production, the gravel acts as a filter bed to screen large sand particles which in turn bridge the smaller sand particles. If the proper gravel size is selected for gravel packing, this method of sand exclusion permits a filter bed of high permeability to exist in the perforation holes and around the screen inside the casing. Because of the small diameter of the screen that may be run through the well tubing and the length of blank liner that extends into the well tubing, this method of sand control is limited to low productivity wells and to zones that are located a short distance from the end of the well tubing.

Sandlock. The Sandlock process utilizes plastic-coated walnut shells to fill the perforation holes and cavity between the formation sand face and casing. The plastic coating on the walnut shells will harden and bond the ground and graded shells together forming a very permeable filter bed. Aluminum tubing extension may be used to place the walnut shells in the same manner as a set-through cement job with the lower end of the extension located at the lowest point in the well that must be kept clean of shells. The wireline workover permits the entire well to be circulated with oil prior to performing the Sandlock job and the well need never be killed with drilling mud, thereby performing the job in the best possible environment. This process of sand exclusion is very attractive for permanently completed wells because of the low cost, the high permeability of the deposited shells, and the fact that no screen is used leaving the well bore open for future operations.

Consolidating Plastic. When the formation permeability is fairly high, consolidating plastic may be used to bond together the formation sand grains. The type and amount of plastic and catalyst depend upon formation temperature and necessary placement time. Again the aluminum tubing extension is set through the perforated interval and the well may be circulated with oil prior to squeezing the consolidating plastic into the formation. Again, the permanent completion technique permits the almost perfect method of using consolidating plastic since the perforations are clean and the sand face is not covered with drilling mud. Crude oil should be used with consolidating plastic and is much more easily handled with wireline equipment than with conventional rig equipment. Consolidating plastic is more expensive than Sandlock material, but the placement technique is somewhat similar. More workover time may be involved with consolidating plastic because a second batch of plastic is always used, whereas the second stage of a Sandlock treatment may not be required.

DUAL COMPLETIONS

The technique of reworking the lower completion of a dually completed well is the same as that for reworking a singly completed well containing a packer with one exception — the upper zone must be isolated from the system during a portion of the remedial operations. If the upper zone has not caused lost circulation problems, it may be unnecessary to isolate this zone except during cementing operations.

The parallel-string dual completion, shown in Fig. 10, is reworked through the lower zone tubing string in the same manner as a single completion with a packer since the upper zone is confined by the installation. Production may continue through the second string during the workover if the casing annulus is not utilized for upper zone artificial lift purposes.

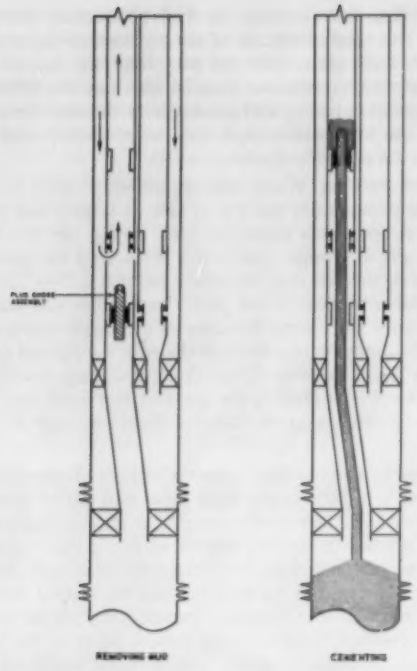


FIG. 10. **Parallel-String Dual Completion.** The lower zone can be re-worked just as a single completion. Should the upper zone become sanded between packers, sand removal operations can be conducted through the upper zone tubing, provided the bore through the packer will pass a small extension pipe.

Should the upper zone become sanded between packers, sand removal operations may be conducted through the upper zone tubing string in the same manner as a single completion, provided the bore through the packer and tubing will pass small extension pipe.

The single-string dual completion, shown in Fig. 11, may be reworked by isolating the upper zone from the system with a bypass tool that is installed at the proper distance below the extension hanger to seal the ports in the side-port nipple. The position of this packing section in the extension is determined from the position of packing on the choke assembly previously pulled from the well. This bypass test assembly permits pressure testing of the well tubing, casing, and packers before performing any remedial operation such as cementing. It is necessary to kill both zones of a dual well before performing remedial operations, and it is also necessary to bring in both zones before reinstalling the straight flow or crossover flow choke.

WORKOVER RESULTS

When the permanent completion process was in its initial development stage, the results of low-pressure squeeze-cement jobs performed as attempts to reduce gas or water ratios were sometimes doubted, particularly on wildcat wells. On about a dozen occasions, a conventional workover rig employing the high-pressure squeeze-cementing technique was used following a wireline workover in an effort to improve the producing characteristics of a well. On no occasion did the conventional techniques improve the producing ratios; and in every case, later reservoir analysis proved that this producing ratio was characteristic of the perforated zone.

Recently, a wireline workover was employed with the low-pressure squeeze-cementing technique to successfully reduce water production and re-establish oil production in an offshore well after nine unsuccessful high-pressure squeeze-cementing attempts. Also recently, a wireline workover was successfully used to eliminate excessive gas production in a dually completed well located in inland waters after three unsuccessful squeeze-cementing attempts with a drilling rig. These two outstanding successes of the wireline workover technique, as compared to the conventional workover technique, may be attributed to the elimination of drilling mud during the workover and squeeze-cementing operations and thereby the elimination of mud-plugged perforations.

The use of the tubing-type perforator with the proper completion fluid has permitted the early release of drilling rigs, and in many cases has increased well productivity.

Perforating in a nonplugging fluid will also decrease future wireline workover costs since the success of squeeze-cement jobs will be increased due to the elimination of mud-plugged perforations. Of additional importance is the possibility of less formation sand production because of more open perforations. When wells completed in unconsolidated sands produce excessive formation sand, it is possible to obtain more effective sand control because of unplugged perforations.

When analyzing wireline workover results and the economics of this type completion, it is apparent that there has been a decided reduction in difficulties such as line breakage, equipment failures, and errors in judgment, possibly because of more experience and because of coordination between service personnel and oil company personnel.

Less than 5 per cent of the workovers attempted with a wireline must be completed with a rig and generally this is due to holes in the tubing or casing or the malfunction of subsurface equipment. With the advent of the wireline workover has come an increase in the number of formation tests per workover. Geologists have taken advantage of the low cost of the permanent completion technique to test all possible fluid producing formations penetrated by the well bore. * * *

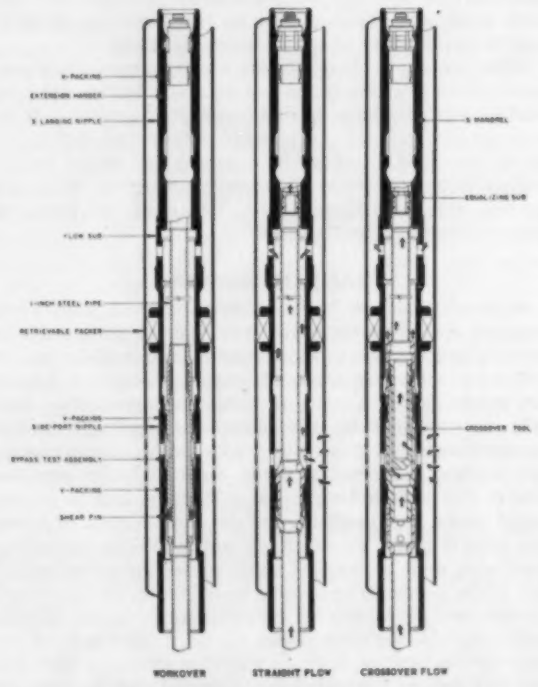


FIG. 11. **Single-string dual completion** with side-port nipple may be re-worked by isolating the upper zone from the system with a bypass tool.

About 125 frac jobs a day — or more than 44,000 jobs per year are done in the U. S. Over 120,000 of the country's 570,000 wells have been fractured. Average treatment today is about 7500 gallons of carrying agent and 15,000 pounds of sand.

SPECIAL *Well Workover* FEATURE

The How's and Why's of . . .

Well Stimulation By Fracturing

P 532.

Fracturing is the number one workover for well stimulation. Today, 23 per cent of the wells in the U. S. have been fractured.
Here's an easy-to-understand analysis of how fracturing works and what it does

M. J. Kaufman
Phillips Petroleum Co., Bartlesville, Oklahoma

WELL fracturing is big business. At the beginning of the year, about 30 service companies were in the fracturing business and 23 per cent, or 120,000 out of the 527,000 wells in the U. S. had been fractured. The current rate of fracture treatments for the industry is approximately 125 jobs per day.

The size of treatments has steadily increased throughout the history of fracturing. The average size treatment today is about 7500 gallons of carrying agent and 15,000 lbs of sand. Early injection rates of 1 to 5 bbl per minute are low compared to injection rates of 60 bbl per minute which are sometimes used today.

Classification of fracture treatments. Since 1949, various carrying agents and various techniques for fracturing oil and gas formations have been developed. At least 28 different trade names have been used to describe fracture treatments. Classification of fracture treatments in terms of the fluid used to carry the sand shows that six general types of carrying agents are in use — **hydrocarbon base gels or emulsions, combination hydrocarbon and acid base gels or emulsions, acid base gels or emulsions, refined oils, crude oils, and water or water base gels.** Additives have been developed for carrying agents to increase viscosity, reduce fluid loss, and cause the carrying agent to revert to a low viscosity fluid.

Plugging agents. Study of early, small size, fracture treatments showed that only one fracture was usually created with each job. Calculations indicated that if one fracture resulted in a substantial production increase, two or more fractures would result in even large production increases. *As a result, temporary plugging agents were developed to aid in the creation of multiple fractures.*[6] At least 13 different trade names are applied to plugging agents used in conjunction with fracture treatments.

History of Formation Fracturing

Creating fractures in oil and gas producing formations dates from early days of shooting with nitroglycerin when it was recognized that part of the resulting production increase was due to cracking the producing formation.[1] Observation of the "pressure break" which occurred during early acid jobs, oil injection treatments, or squeeze cement jobs, indicated

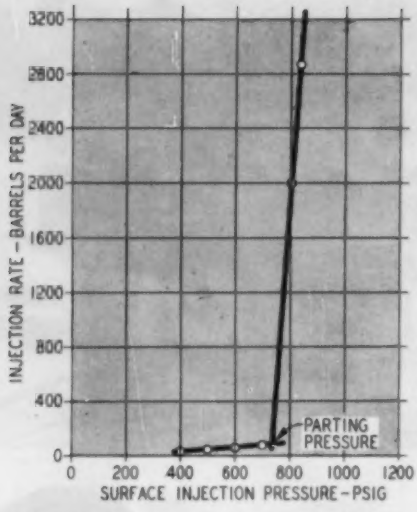


FIG. 1. "Parting Pressure" is graphically illustrated here. On a test conducted nearly 10 years ago, the injection rate increased proportionately to injection pressure until the "parting pressure" was reached and the formation fractured. Thereafter, a slight increase in pressure resulted in a large increase in injection rate. Test is on Bartlesville Sand in Eastern Kansas.

that the formation was being parted or fractured by hydraulic pressure.[2]

The terms *parting pressure* or *lifting the overburden* came into common usage with the development of waterfloods.[3, 4] Fig. 1 is a plot of injection rate in bbl per day against surface injection pressure on a Bartlesville Sand water injection well in Eastern Kansas. The data were taken on a test conducted nearly 10 years ago. As the surface injection pressure was increased, the injection rate increased proportionately until a certain pressure was reached. Thereafter, a small increase in pressure resulted in a large increase in water injection rate. The pressure at which the rate of injection increased was called *parting pressure*. The formation was actually parted or fractured at the parting pressure and the fracture remained open until the surface injection pressure was reduced below the parting pressure. A logical development was to utilize a mechanical propping agent to hold the fracture open and apply the process to a production well. By 1949 the gradual natural development of these processes had reached the point where service companies were offering to fracture formations for production companies under various trade-mark names, such as Hydrafrac treatment.[5]

Recent Developments

In addition to larger size jobs performed at higher injection rates, a recent technique for increasing the average sand concentration and reducing the danger of a "screen-out" has been developed. The sand concentration in pounds per gallon is continually increased during treatment.[7] For example, the first 1000 gal of treating fluid might contain a sand concentration of one-half pound per gal; the second 1000 gal might contain one lb per gal; the third 1000 gal might contain one and one-half pounds per gal; and the balance of the carrying agent might contain two lb per gal. Concentrations as high as eight pounds per gal have been reached on certain experimental jobs. Service companies have equipment available for varying the sand concentration as the fracture treatment is being performed.

Vertical Fracturing. Another recent technique in fracture treatments is known as vertical fracturing.[8] Experimental laboratory work showed that vertical fractures could be developed by "plastering" the walls of a bore hole to prevent horizontal fractures which normally occur at lower pressures than vertical fractures. In a homogeneous reservoir it would make little difference whether a horizontal or a vertical fracture were created. But oil and gas reservoirs are not homogeneous, and the horizontal permeability is usually greater than the vertical permeability. The difference between horizontal and vertical permeability is significant in some reservoirs because of shale streaks or other impermeable material interbedded with oil bearing rock. If a horizontal fracture were created in this type of reservoir as illustrated in Fig. 2, it is probable that only one of the small porous zones would be fractured, and any increased production rate would decline rapidly. If it were possible to fracture this type of reservoir vertically as shown in Fig. 3, most of the thin, porous zones would be fractured and a less rapid production decline could be expected.

First field trials of the vertical fracturing technique were conducted in a sandstone reservoir which was highly interbedded with shale streaks. The well bore was "plastered" with oil-base mud and lost circulation material. Treating fluids were then injected into the well and, as indicated by previous laboratory work, the breakdown pressure was considerably higher than would be expected in conventional fracturing. Permeabil-

FIG. 2. Horizontal and vertical permeability vary widely in some reservoirs where shale streaks are interbedded with oil bearing rock. If horizontal fracturing is used, it is probable that only small porous zones would be fractured, and increased production rate would decline rapidly.

FIG. 3. Vertical fracture if possible would probably pay off in this type reservoir (same as the one shown in Fig. 2) because most of the thin porous zones would be fractured and a less rapid production decline could be expected. Vertical fractures are difficult to obtain.

The Author

M. J. Kaufman is an area supervising petroleum engineer in the Production Department of Phillips Petroleum Company in Bartlesville, Oklahoma. He has served in various production engineering capacities for Phillips in Kansas, Oklahoma and Texas. He is a native of Kansas and graduated from the University of Kansas with a BS degree in petroleum engineering in 1947, immediately before joining Phillips Petroleum.

ity surveys before and after treatment showed that the permeability was increased through the entire producing zone and a more sustained production increase was realized. Conventional fracture treatments of offset wells had resulted in favorable initial responses followed by comparatively rapid declines in production.

Vertical fractures are no doubt desirable in many reservoirs, but method described above is regarded as a specialized technique applicable only in extreme cases because of the added cost and the danger of possible damage to the well. The likelihood of obtaining a vertical fracture without "plastering" the bore hole can be increased by the use of viscus, low fluid loss carrying agents and high injection rates. Conversely, injection of high fluid loss, low viscosity, carrying agents at low rates will enhance the possibility of creating horizontal fractures.

Success ratio of fracturing. The spectacular production increases obtained by fracture treatments might indicate that it would be profitable to fracture every well. *Profitable results have been realized from about 75 per cent of the fracture treatments which have been attempted.* The fact that some treatments are unsuccessful makes it desirable to examine the factors which will improve the chances of successful treatments.

Criteria for Selecting Wells for Fracture Treatment

Criteria for selecting wells for treatment have not changed materially since 1950, but recent results show that a liberalized interpretation of the various factors is now justified.[6, 9, 10]

State of Depletion of the Producing Formation. Fracture treatments are successful in increasing oil and gas production rates because they increase permeability in the vicinity of the well bore. If a formation is depleted of reservoir energy, no amount of increased well bore permeability will give commercial oil production. Larger and more sustained production increases can be expected if fracture treatments are used early in the life of the field, but results have shown that successful treatments can be performed in old fields where pressures are comparatively low.

Formation Composition and Consolidation. Successful fracture treatments can be performed in limestone, dolomite, sandstone, and conglomerate pay formations. Fracture treatments are not considered applicable in unconsolidated formations.

Formation Permeability. As the permeability of the formation approaches the permeability of the created fracture, the production increase which is possible approaches zero. Therefore, a large production increase, expressed in per cent of natural production, can be expected from fracturing low permeability pay zones than high permeability pay zones.

Formation Thickness. Calculations and early experience indicated that better results could be expected in thin producing zones than in thick ones. Vertical fracturing techniques, multiple fracturing techniques, large-size jobs, and high injection rates have reduced the importance of formation thickness to the extent that it is no longer a practical consideration in the selection of wells for fracture treatment.

Previous Reconditioning. It was reasoned from study of early fracture treatments that a well in which the permeability had already been improved by some type of well treatment would not respond to fracture treatment sufficiently to make fracturing profitable. Wells from which production increases were obtained by small-size fracture treatments are good candidates for retreatment, and wells which have been acidized or shot can be fractured successfully. New techniques, large-size jobs, high injection rates, improved and more economical carrying agents are important factors responsible for highly successful fracture treatments of wells that have been treated previously by well stimulation methods.

Isolation of the Zone to be Treated. Injected treating fluids will follow the path of least resistance. No oil production increase can be expected if a fracture is created in cement, shale, or coal, instead of the producing zone. The practice of extending perforations a few feet beyond the upper and lower limits of a pay zone to be sure that all of the productive zone would be perforated, has been revised in several areas. The revised practice of perforating only within the indicated limits of a pay zone has been adopted so that treating materials and the resulting fractures will be confined to the productive portions of the pay zone.

Condition of Well Equipment. Bottomhole treating pressures of one pound per foot of depth should be expected, and working pressure ratings of well equipment should be sufficient to withstand these pressures.

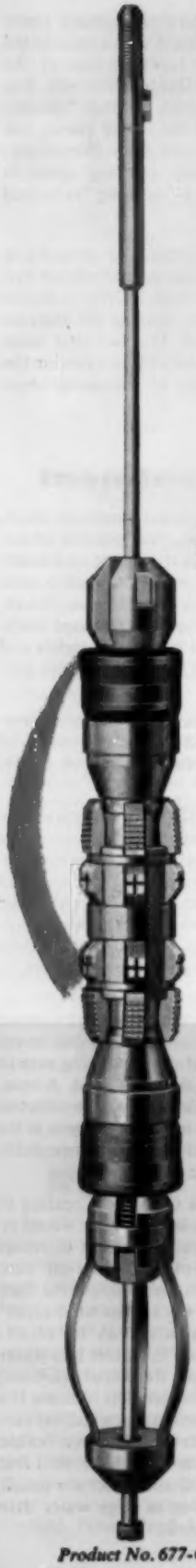
Production History of the Well. Wells with comparatively flat or steep production decline curves offer good opportunities for fracture treatment. A comparatively flat production decline curve indicates that the well is draining a large area and that the rate of drainage can be increased by improving the permeability near the well bore. A comparatively steep production decline curve indicates that the well may be draining a limited area and that the production rate can be increased by extending the radius of drainage.

Offset Production History. If a well produces at a lower rate than offset wells, a large production increase can be expected from fracture treatment than if the producing rate of the well is higher than other wells in the same pool. A comparatively low rate of production indicates that the effective permeability near the well is less than in adjacent areas in the same pool. Fracture treatment will likely increase permeability near the well and thereby increase the production rate.

Location of Water-Oil and Gas-Oil Contacts. Creating or extending fractures into a water or gas-bearing zone would result in increased water-oil or gas-oil ratios without increased oil production. No change in gas-oil or water-oil ratio should be expected from fracture treatment unless the fracture is created in a water or gas zone. Recent, isolated experience has indicated that vertical fractures can be created unintentionally that may extend as much as 60 feet into water-bearing zones below the producing zone. Results of fracturing in water drive reservoirs and waterflood projects indicate that the danger of adversely affecting the producing water-oil ratio is greatest in bottom water drive reservoirs or when bottom water is present. Efforts should be made to avoid vertical fractures when bottom water is present. Oil and water are usually increased proportionately by fracturing in edge water drive reservoirs and in lateral drive waterfloods.

FRACTURE
ACIDIZE
SWAB *and* TEST

as many intervals as required



Product No. 677-C

... *in one round trip*

with BAKER RETRIEVABLE BRIDGE PLUG *and...*

SETS AND PACKS OFF AGAINST PRESSURE DIFFERENTIALS FROM EITHER ABOVE OR BELOW

After the Retrievable Bridge Plug has been run to the desired depth and released, it will automatically set and pack off against pressure differentials established from either above or below the tool.

CAN BE RUN IN AND RETRIEVED EASILY... OR MOVED AND RESET AS MANY TIMES AS REQUIRED

The number of times that the Retrievable Bridge Plug can be released, moved and reset is limited only by the number of operations in the well that require its use.

NUMEROUS ECONOMICAL APPLICATIONS

Used WITH the Baker Full-Bore Retrievable Cementer for:

(a) *Straddle Operations*
The distance to be straddled is not limited by the made-up length of tool.

(b) *MULTIPLE Zone or Selective Testing, Fracturing, Acidizing*

Used BY ITSELF for:

(a) "Down-the-casing" Fracturing or Acidizing

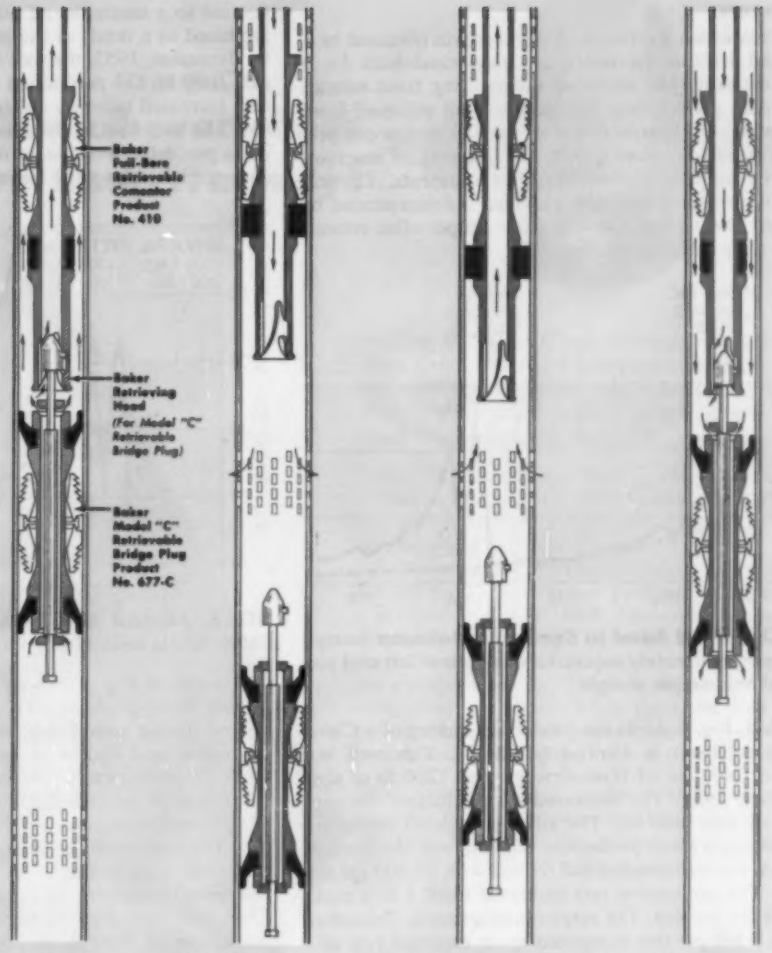
(b) Testing operations

(c) Temporary pressure containment to permit repair to or removal of well head equipment with safety.

Write for Catalog Supplement No. 319 for complete information on

TYPICAL OPERATION

Product No. 410


Baker Full-Bore Retrievable Cementer Product No. 410
Baker Retrieving Head (For Model "C" Retrievable Bridge Plug)
Baker Model "C" Retrievable Bridge Plug Product No. 677-C

RUNNING-IN
Retrievable Bridge Plug being run into well on bottom of Full-Bore Cementer through use of Retrieving Head. Note fluid by-pass.

FRACTURING OR ACIDIZING
Plug should be pressure tested after release. Cementer is released, raised above perforations and reset for pressure operations.

SWABBING, TESTING
Note how the reversal of pressure differential has transferred load from one set of slips to the other (both cementer and plug).

RETRIEVING
Plug and Cementer being moved to next set of perforations—or retrieved from well. Valves in plug open to permit fluid by-pass.

BAKER FULL-BORE RETRIEVABLE CEMENTER

HOLDS PRESSURE FROM EITHER ABOVE OR BELOW

Two sets of opposed slips enable the cementer to hold pressure from either above or below. Casing can be tested before squeeze—and the tubing also, if the Baker Full-Bore Tubing Tester is used.

FULL BORE CONSTRUCTION

Permits Passage of Tubing Perforators or Instruments—Assists in Preventing "Screen-Out" on Fracturing Jobs

The Full Bore through the Cementer (and Tester if used) is in reality a continuation of the bore through the tubing.

This continuous full ID passage not only permits passage of tubing perforators or instruments but assists in preventing "Screen-Out" (sand dropping out of the oil) and subsequent plugging of the tubing in fracturing jobs.

IDEAL STRADDLE TOOL WHEN USED WITH BAKER RETRIEVABLE BRIDGE PLUG

The operation of the Cementer setting mechanism makes it easy (through the use of the Retrievable Bridge Plug Retrieving Head) to release and pick-up the Baker Retrievable Bridge Plug. It is in fact the ideal partner to the Retrievable Bridge Plug for selective multiple-zone or single-zone operations.

these products and their application

BAKER OIL TOOLS, INC.
HOUSTON • LOS ANGELES • NEW YORK

Retreatments

Wells from which a production increase was obtained by a small, initial fracture treatment are good candidates for a larger retreatment. The increased oil resulting from retreatments is often greater than the increased oil obtained from original treatments. Results of retreatment show that one precaution is justified — that a sufficient amount of reservoir pressure is remaining at the time of retreatments. The importance of remaining reservoir pressure is demonstrated by the fact that the decline rate is usually steeper after retreatment than after initial treatments.

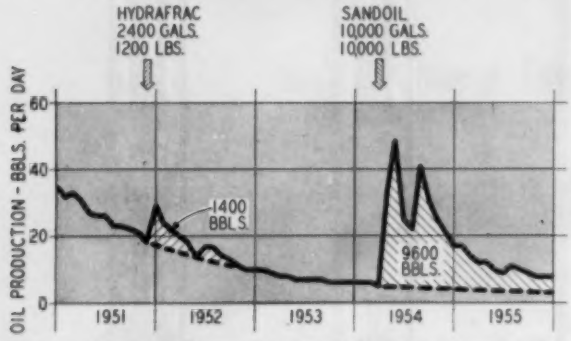


FIG. 4. **Cleveland Sand in Central Oklahoma** fracturing job shows moderately successful small job at left and successful high volume job at right.

Example 1. Fig. 4 shows the production history of a Cleveland Sand producer in Central Oklahoma. This well was treated with 2400 gal of Hydrafrac gel and 1200 lb of sand in December, 1951. The increased oil production obtained from this job was 1400 bbl. The job is considered unsuccessful even though a small production increase was obtained. In April, 1954, the well was Sandoil treated with 10,000 gal and 10,000 lb. The production rate increased from 5 to a maximum of 49 bbl per day. The rate of production in December, 1955, was 7 bbl per day compared to an expected rate of 3 bbl of oil per day without fracture treatment. The increased oil recovered from the rate of the second treatment to the end of 1955 was 9600 bbl.

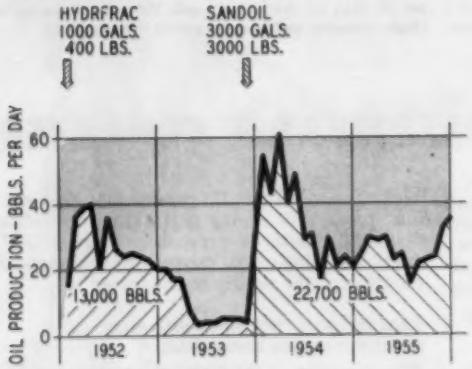


FIG. 5. **First Wilcox Sand Central Oklahoma.** Fracturing made a non-commercial oil well a commercial one. Fracture job at left was on initial completion.

Example 2. Fig. 5 pictures the production history of a First Wilcox Sand producer in Central Oklahoma. The well was treated with 1000 gal of Hydrafrac gel and 400 lb of sand during completion. The well had a natural production of only one-half bbl per day and would not have been commercial without the initial Hydrafrac treatment which increased production to a maximum of 40 bbl per day. The increased oil produced as a result of the initial treatment was 13,000 bbl. In December, 1953, the well as Sandoil treated with 3000 gal and 3000 lb. Oil production increased from 4 to 60 bbl per day. Increased recovery due to the second treatment is 22,700 bbl. The two fracture treatments can be credited with making a profitable well out of one which would not have been commercial without the fracture treatments.

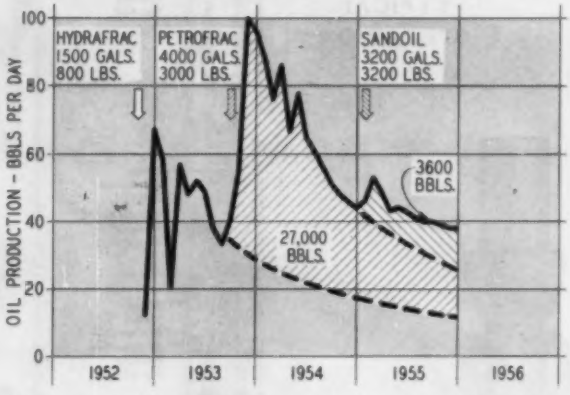


FIG. 6. **Second Muddy Sand in Central Wyoming.** Retreatments were highly successful.

Example 3. Fig. 6 shows a production history of a Second Muddy Sand producer in Central Wyoming. The well was treated during completion in October, 1952, with 1500 gal Hydrafrac and 800 lb of sand. Production increased from 20 to a maximum of 67 bbl of oil per day. A Petrofrac treatment of 4000 gal and 3000 lb during October, 1953, resulted in a production increase from 35 to a maximum of 100 bbl per day. Total increased production from the date of the second treatment to the end of 1955, of 27,000 bbl can be credited to the second treatment. In January, 1955, the well was given a Sandoil treatment of 3200 gal and 3200 lb. Total increased production of 3600 bbl can be credited to the third treatment to the end of 1955.

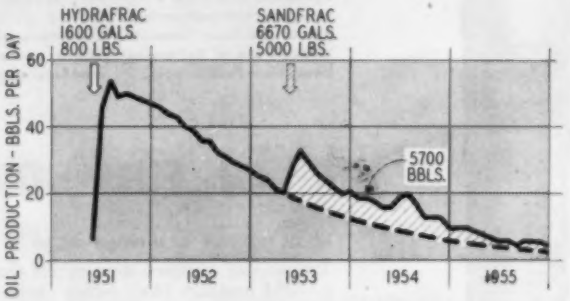
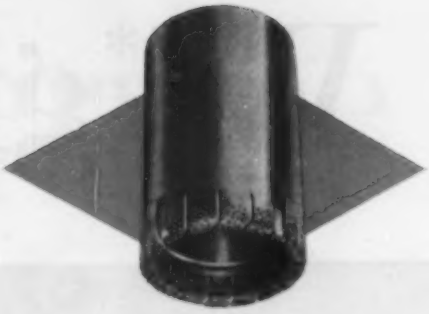


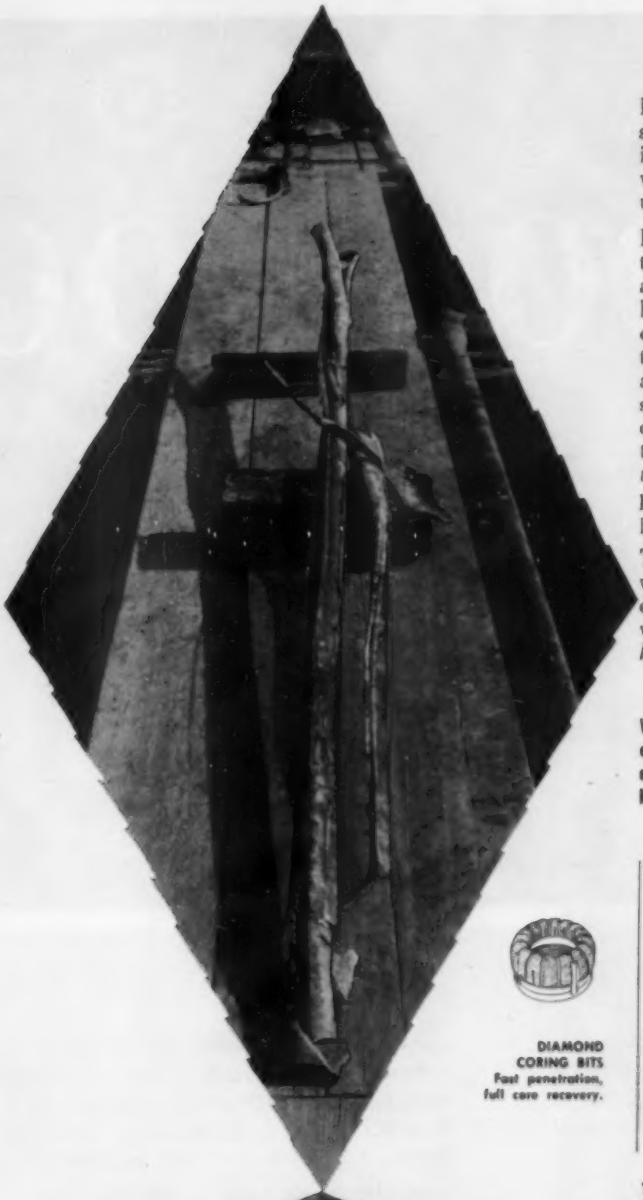
FIG. 7. **Hart Sand in Southern Oklahoma.** Moderate success with retreatment.

Example 4. Fig. 7 shows the production history of a Hart Sand well in Southern Oklahoma. The well was treated during completion in June, 1951, with 1600 gal Hydrafrac gel and 800 lb of sand. Oil production increased from 20 to 56 bbl per day. A Sandfrac treatment of 6670 gal and 5000 lb during May, 1953, increased production from 20 to 33 bbl per day. Total increased production due to the Sandfrac treatment is 5700 bbl. Production had declined to a rate nearly equal to the expected production rate without fracture treatment by the end of 1955.

Example 5. A most unusual production history is shown in Fig. 8 of a Gibson Sand producer in Southern Oklahoma. The

D & S washover shoes save time... money!





Drilling & Service Truco diamond washover shoes have performed many extraordinary feats in the oilfield. We cite one example here which tells a graphic story of advantages in using D&S washover shoes for *your* operation:

Recently, one customer had 7" casing set through pay zone. The casing was perforated and a packer set with 2½" tubing. When he started to sandfrac the well, the casing collapsed around the tubing. After backing off the tubing... leaving one joint up for a guide, a 5-15/16" x 4-5/8" D&S diamond washover shoe was run on 5½" OD wash pipe... cutting over the tubing, packer and cutting out the collapsed casing. This was done in *three days' rig time!* When the wash pipe was pulled, the tubing, portion collapsed casing, packer and anchor joint were retrieved inside it.

Total Truco diamond washover shoe cost was only $850. Experience in this type of operation has shown that conventional methods would have required *more* rig time and *higher* related costs.

WRITE OR CALL TODAY! One of our sales engineers will call on you and explain our custom-services and equipment. Herein lie the real D&S advantages.

DIAMOND CORING BITS
Fast penetration, full core recovery.

DIAMOND DRILLING BITS
More footage, less rig time.

DIAMOND WASHOVER SHOES
Fast "Fish" recovery.

CORE BARRELS
The standard of the industry.

TRUCO DIAMOND BITS

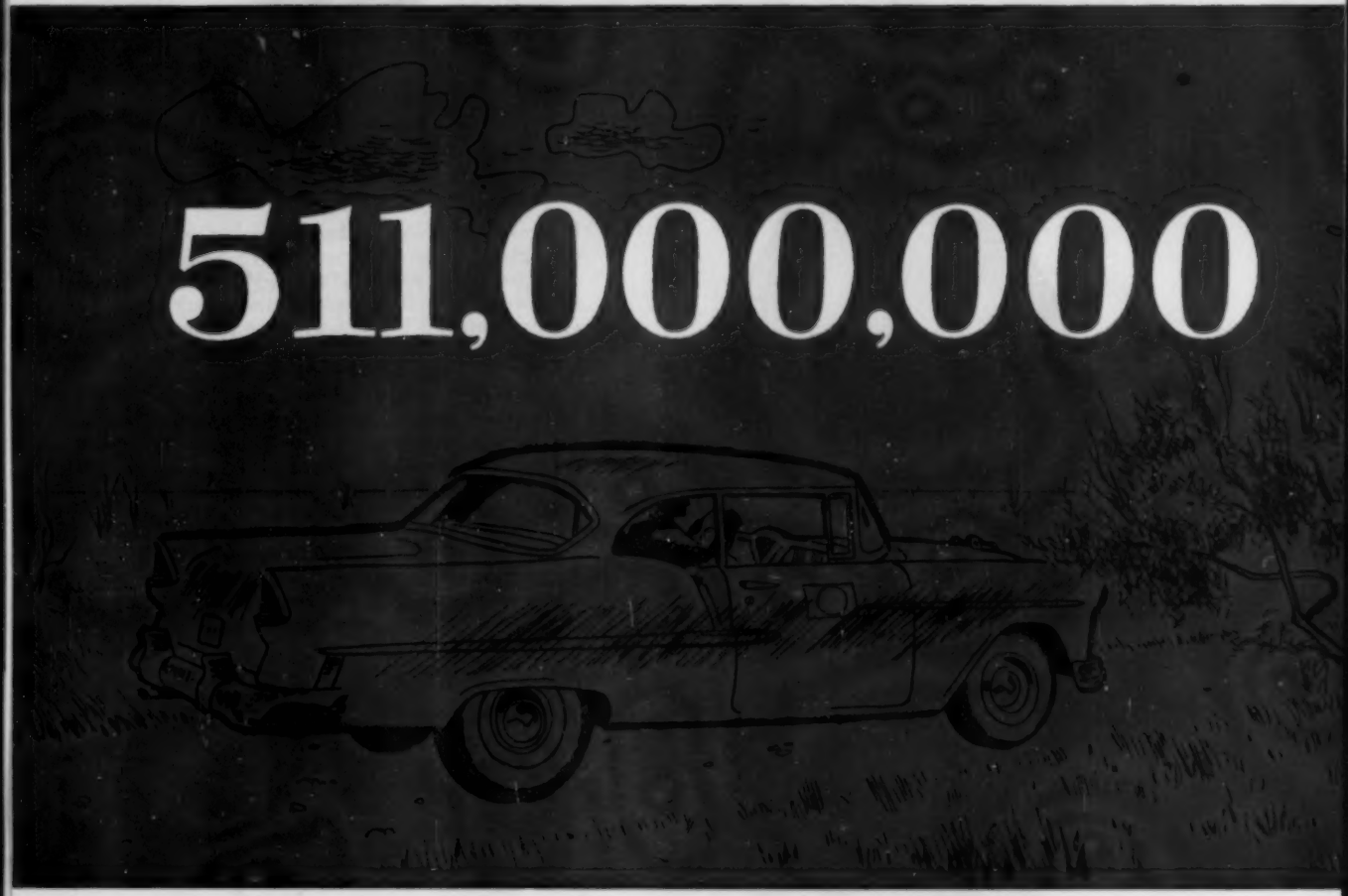
Drilling & Service INC. | DIAMOND DRILLING EQUIPMENT

6210 NORTH CENTRAL EXPRESSWAY | DALLAS, TEXAS

OFFICES IN ALL PRINCIPAL OIL AREAS

Ultra Fine Diamond Equipment for the Oilfield

We* give extrao



Thanks to the spur of keen competition among our members—and their innate desire to back up their continually improved products and special services with helpful technical assistance

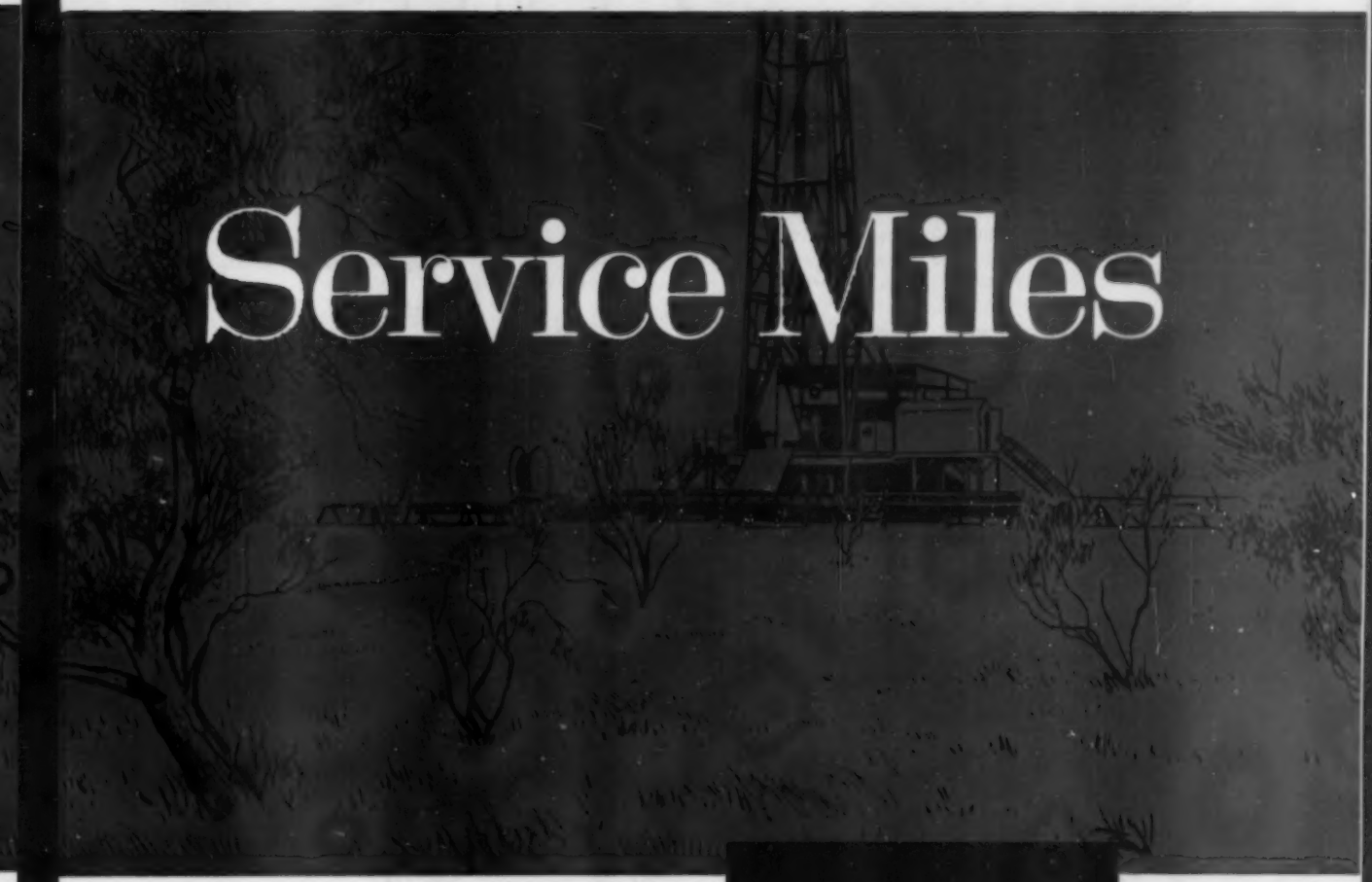
. . . **we*** give our customers outstanding service—as proved by the fact that our service cars, trucks, and pickups travel *511,000,000 service miles a year;*

. . . **we*** back up our products and special services with *9,000 engineers,* composed of research scientists, development engineers, metallurgists, production engineers, and field service engineers;

. . . **we*** back up our products and services with *plants and equipment worth billions of dollars* in order to supply our customers with constantly improved equipment and services in *quantities wanted . . . when wanted . . . where wanted.*

***Manufacturers . . . Supply Companies . . . Service Companies**

rdinary service



Service Miles

P.E.S.A.*

Composed of: manufacturers whose plants make the finest precision equipment . . . supply stores who add two other ingredients of value — where you want it, — when you want it. . . service companies who make available to their customers the practical results of the theoretical research of some of the most brilliant scientific and technical men in the world.

*PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION

well has been fracture treated four times. The first treatment of 750 gal of Hydrafrac gel and 300 lb of sand was performed in June, 1950. Production increased from 30 to 58 bbl per day. Total increased production due to the first treatment is 15,400 bbl. The second treatment, 2400 gal of Hydrafrac gel and 1200 lb of sand, performed during September, 1951, resulted in a production increase from 28 to 53 bbl per day. Total increased production due to the second treatment is 12,100 bbl. The third treatment, a Sandfrac job of 6670 gal and 5000 lb, performed during March, 1953, resulted in a production increase from 20 to 59 bbl per day. Total increased oil due to the third treatment is 17,100 bbl. The fourth treatment, a Sandoil job of 10,000 gal and 10,000 lb was performed during October, 1954. Production was increased from 5 to 13 bbl per day. The total increased oil credited to the fourth treatment is 5200 bbl.

All four treatments can be considered successful. A most important feature about the production history is that the decline rate became steeper after each of the highly successful treatments. The moderate amount of oil recovery credited to the fourth treatment compared to the previous treatments, might be explained by depletion of the producing formation.

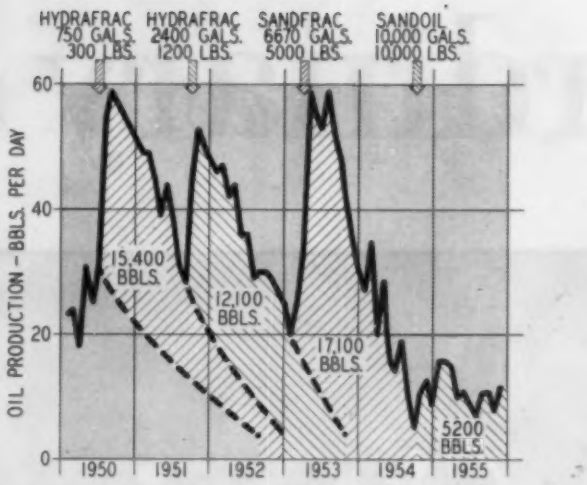


FIG. 8. **Gibson Sand in Southern Oklahoma.** Four treatments — all successful.

Fracture Treatments in Secondary Recovery and Pressure Maintenance Operations

Data available at this time show that fracture treatments are profitable reconditioning procedures in secondary recovery operations. Selected production histories from waterflood and gas injection projects in Eastern Oklahoma, Eastern Kansas, North Central Texas, and the Texas Panhandle, discussed in detail in the following paragraphs, illustrate the beneficial results which can be derived from fracturing in secondary recovery operations.

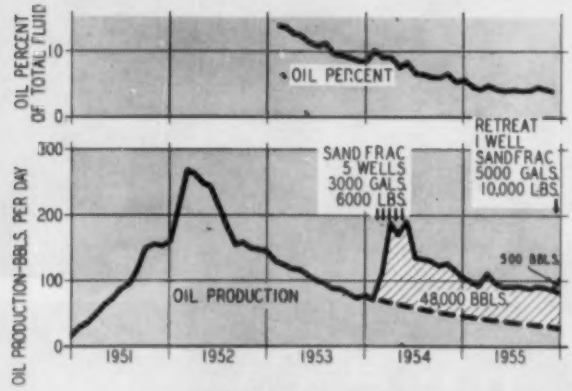


FIG. 9. **Bartlesville Sand in Eastern Oklahoma.** Production history of waterflood shows advantages of fracturing.

Example 1. Fig. 9 shows the entire waterflood production history of a lease in a Bartlesville Sand Pool in Eastern Oklahoma.[11] The flood was developed on a 10-acre, five-spot pattern. Five of the six waterflood producing wells were each fracture treated with 3000 gal and 6000 lb during February, 1954. All of the wells had been shot previously and were fractured late in the life of the flood, long after the flood front had passed the wells. All wells were producing less than 25 per cent oil at the time they were treated. The resulting increase in lease production was from 70 to 190 bbl of oil per day. Individual well tests show that all five jobs were successful and an increased recovery of 48,000 bbl of oil can be credited to the five treatments between February, 1954 and the end of 1955. One well was retreated in December, 1955 with 5000 gal and 10,000 lb. The initial production response indicates that the retreatment was successful, but additional production history will be required to fully evaluate the retreatment. The rate of production from the lease in December, 1955, was 102 bbl per day compared to an expected production rate of 30 bbl per day without the fracture treatments. Oil production expressed as a per cent of total fluid and shown in Fig. 9 improved temporarily as a result of the five fracture treatments.

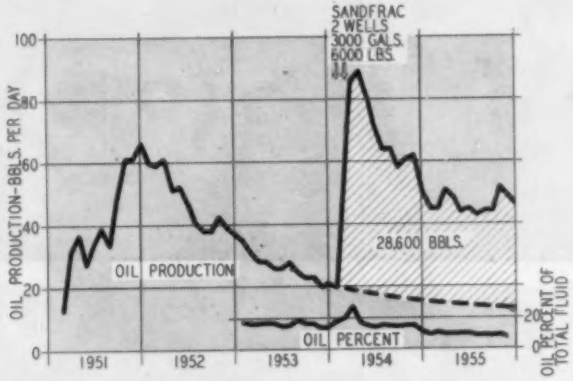


FIG. 10. **Bartlesville Sand in Eastern Oklahoma.** Production history of two wells on 10-acre 5-spot flood.

Example 2. Fig. 10 shows the waterflood production history of a two-well lease in a Bartlesville Sand Pool in Eastern Oklahoma. The flood was developed on a 10-acre, five-spot pattern. Both producing wells were treated during February and March, 1954. One well was producing 37 per cent oil and the other was producing 10 per cent oil at the time of treatment. Lease oil production increased from 20 to a maximum of 89 bbl of oil per day. Peak oil production after fracture treatment was 22 bbl per day higher than peak waterflood oil production. Individual well tests show that both jobs were successful and an increased oil recovery of 28,600 bbl can be credited to the two jobs from February, 1954, to the end of 1955. Oil production expressed as a per cent of total fluid and shown in Fig. 10 increased slightly in both cases.

FIRST FRACTURING FLUID YIELDS LASTING BENEFITS

Halliburton's *Time-Tested*

HYDRAFRAC SERVICE

Making fracture... carrying sand into the fracture ...and leaving it there... is the basic purpose of all hydraulic fracturing operations. Halliburton's HYDRAFRAC process has demonstrated its unmatched ability to do all three. It is the only hydraulic fracturing method with seven years of outstanding success in the field.

HELPS TO EXTEND PROFITABLE PRODUCTION

By leaving more sand in the fracture, the HYDRAFRAC process helps to establish more favorable conditions for profitable production over longer periods. Special chemicals, added to or following the high viscosity gel, cause it to revert to a thin solution within a few hours. This enables the sand to drop out in maximum quantities while still in the fracture and keep flow channels open. After thinning, the fluid is produced from the formation as part of the well's production.

MORE SAND IN THE FRACTURE

High gel strength enables the fracturing fluid to carry high ratios of sand in suspension while pumping down hole. Even under most conditions of low injection rate, Hydrafrac fracturing fluid keeps sand in suspension. This results in a better, more effective fracturing job that will yield longer benefit.

If you have a well that once showed high promise but is turning into a disappointment, the HYDRAFRAC method may be the way to turn potential into profit. It has been doing that for many production-minded men for seven years. A trained, experienced Halliburton field representative will be glad to tell you more. Just call your nearest local or district office of the Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

COMPLETE DATA SENT ON REQUEST

Get this valuable information for your Halliburton Service File

you make the best of all the breaks with

HALLIBURTON FRACTURING SERVICES

251 SERVICE CENTERS – JUST MINUTES AWAY FROM ANY RIG

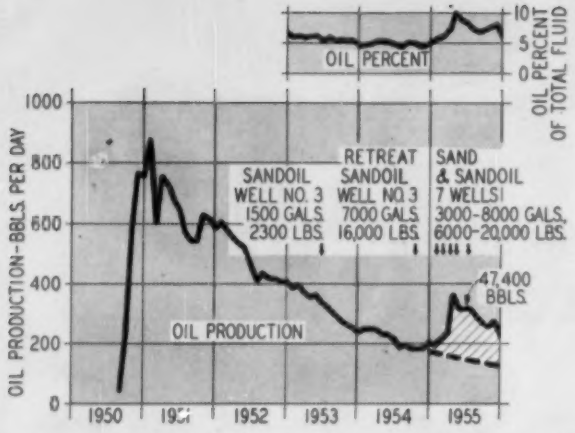


FIG. 11. **Burbank Sand in Eastern Oklahoma.** Pilot waterflood production history shows treatments pay off 47,400 bbls.

Example 3. Fig. 11 shows the production history of a pilot waterflood area of a Burbank Sand pool in Eastern Oklahoma. The pilot area was developed on a 10-acre, five-spot pattern. Eight wells have been refractured and one well has been retreated. The production history shown is for 16 producing wells in the pilot area. The increased oil produced during 1955 as a result of the eight treatments and one retreatment amounts to 47,400 bbl. The production rate during December, 1955, was 95 bbl per day higher than the expected oil production rate without the fracture treatments.

Example 4. Fig. 12 shows the production history of a Bartlesville Sand waterflood producing well in Eastern Kansas. This flood was developed on a 10-acre, five-spot pattern. A Visofrac treatment of 10,000 gal and 20,000 lb was performed on the well in July, 1955. The production rate increased from 18 to 84 bbl of oil per day. The total increased oil recovery during the last half of 1955 was 7500 bbl. The production rate in December, 1955, was 36 bbl of oil per day compared to an expected rate of 18 bbl of oil per day without the fracture treatment. A temporary improvement in oil percentage resulted from the fracture treatment.

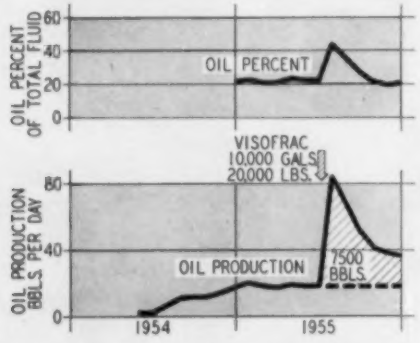


FIG. 12. **Bartlesville Sand in Eastern Kansas.** Temporary improvement in oil percentage from fracturing.

Example 5. Fig. 13 shows the production history of another waterflood producing well in a Bartlesville Sand flood in Eastern Kansas. The flood was developed on a 12-acre, five-spot pattern. A Visofrac treatment consisting of 10,000 gal and 20,000 lb was performed on the well in May, 1955. Production increased from 8 to 82 bbl per day. The total increased oil recovery credited to the job during the last eight months of 1955 is 6900 bbl. The production rate during December, 1955, was equal to the expected rate without fracture treatment. A temporary improvement in oil percentage resulted from the treatment.

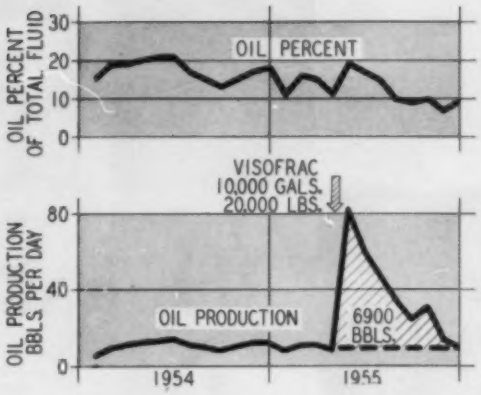


FIG. 13. **Bartlesville Sand in Eastern Kansas.** Another temporary improvement in oil percentage from fracturing.

Example 6. Fig. 14 pictures the injection history of an injection well and the combined oil production history of four offsets to the injection well located in a Bartlesville Sand waterflood in Eastern Kansas. The flood was developed on a 20-acre, five-spot pattern. The injection well was treated with 2500 gal of Hydrafrac gel and 5000 lb of sand during December, 1953. The water injection rate increased from 100 to 400 bbl per day and the combined oil production of four offsets to the injection well increased from 115 to 148 bbl of oil per day. The increased oil production from the four offsets during 1954 and 1955 was 7000 bbl. One of the offset producing wells was fracture treated during October, 1955, and the production history reveals an increased oil recovery of 2000 bbl from October, 1955, to the end of the year.

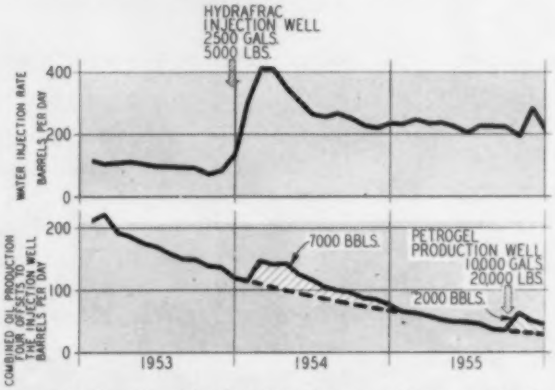

HYDRAFRAC INJECTION WELL 2500 GALS. 5000 LBS.
WATER INJECTION RATE BARRELS PER DAY
COMBINED OIL PRODUCTION FOUR OFFSETS TO THE INJECTION WELL BARRELS PER DAY
7000 BBLS.
PETROGEL PRODUCTION WELL 10,000 GALS. 20,000 LBS.
2000 BBLS.
1953
1954
1955

FIG. 14. **Bartlesville Sand in Eastern Kansas.** Fracturing of injection well gives increased oil recovery.

Example 7. The cost of fracturing injection wells must be returned from increased oil production from production wells before a job can be considered successful. One common fault is evaluating fracture treatment of input wells is the practice of measuring only injection rates before and after treatment. Fig. 15 pictures a case in which water injection rates were increased without an attendant increase in oil production on another Bartlesville Sand waterflood in Eastern Kansas. The injection well was treated with 2500 gal of water base gel and 5000 lb of sand during June, 1954. The injection rate and production rates of offset wells had been reduced because of proration during October, 1953. When proration was lifted,

This is the better, easier way to pump oil wells...

IT IS, OF COURSE, THE KOBE HYDRAULIC OIL WELL PUMPING SYSTEM

Because... IT COSTS LESS TO INSTALL

IT COSTS LESS TO MAINTAIN

IT COSTS LESS TO OPERATE

IT OFFERS A SIMPLE SOLUTION TO PRODUCTION PROBLEMS

IT SIMPLIFIES LEASE PLANNING

IT IS 100% SALVAGEABLE

Free Pump®

KOBE

HUNTINGTON PARK, CALIFORNIA

the former injection and production rates could not be resumed for some unknown reason. The water injection rate was increased by fracture treatment from 20 to nearly 400 bbl per day, but no effect on oil production rates from the four offsets or any other wells in the area could be found. One of the four offset producing wells was fractured in December, 1955, and the production history shown indicates that the treatment was successful.

These results illustrate the application of fracture treatments in waterflood operations. One conclusion is that larger increases in oil production can be obtained from fracture treatment of production wells than of water injection wells. It is also significant that fracture treatment volumes up to 10,000 gal and 20,000 lb have been used with beneficial results on production wells in waterfloods that are developed on 10-acre, five-spot spacing plans. Oil production, expressed as a per cent of total fluid, can be expected to improve slightly or remain unaffected from fracture treatment of waterflood production wells.

Example 8. Successful results have also been obtained from fracture treatments of producing wells in gas injection projects. Fig. 16 shows the production history of a three-well lease located in the Watkins Repressure Project in the Texas Panhandle. Production is obtained from the Brown Dolomite. Well No. 2 was fractured in February, 1955 with 3500 gal and 6000 lb. Lease production increased from 13 to a maximum of 39 bbl of oil per day. A total of 2800 additional bbl of oil can be credited to the treatment to the end of 1955. There was no increase in gas-oil ratio as a result of fracturing.

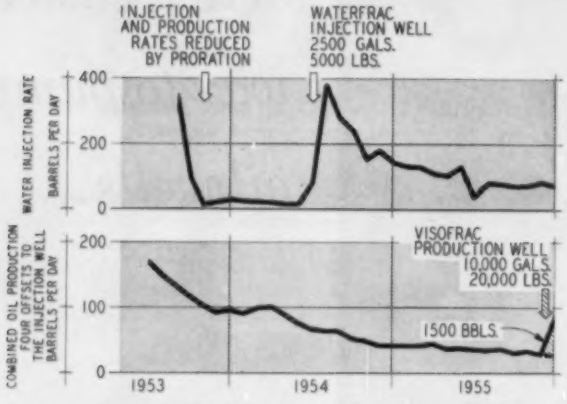


FIG. 15. **Bartlesville Sand in Eastern Kansas.** Fracture job increases water injection but not oil recovery until oil well was fractured.

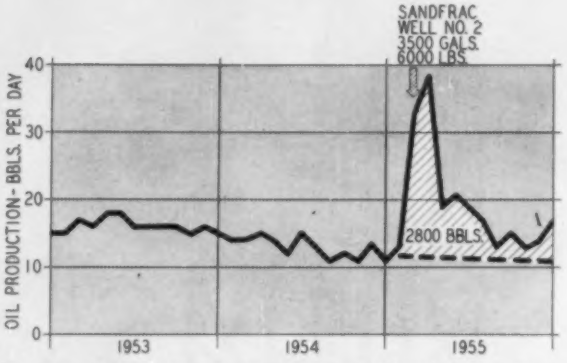


FIG. 16. **Brown Dolomite in Texas Panhandle.** Fracturing gas injection well increases production without increasing gas-oil ratio.

The nearest gas injection well is located 660 ft from Well No. 2.

Example 9. Fig. 17 shows the production history of a lease located in the Hull-Silk Gas Repressure Project in North Central Texas. Production is obtained from the 4300 ft Strawn Sand. Five wells on the lease were fractured between July, 1954 and the end of the year. Lease production increased from 38 to a maximum of 111 bbl of oil per day. Additional production of 31,700 bbl of oil has been recovered in the 18 months from July, 1954 to the end of 1955. Production in December, 1955, was 44 bbl per day higher than the expected production rate without fracture treatments. No increase in gas-oil ratio has been noted on any of the wells.

FIG. 17. **Strawn Sand in North Central Texas.** Fracturing is successful on Hull-Silk Repressure Project.

Fracturing Established

Fracture treatments are well established completion or reconditioning procedures. Criteria for selection of wells are necessary to increase the percentage of successful treatments. Wells from which a production increase was obtained by a small, initial fracture treatment are good candidates for a larger retreatment. Beneficial results can be derived from fracture treatments in water injection and gas injection operations. Larger production increases should be expected from fracturing production wells than water injection wells. Oil production, expressed as a per cent of total fluid, can be expected to improve slightly or remain unaffected from fracture treatment of waterflood production wells. Gas-oil ratios are usually unaffected by fracturing production wells in gas injection operations.

Reference

1. Rison, C. O., "Manufacture of Nitroglycerine and Use of High Explosives in Oil and Gas Wells," *Trans. Am. Inst. Mining Met. Engrs.* 240 (1928-29).
2. Grebe, John J., and Stosser, S. M., "Increasing Crude Production 20,000,000 Barrels from Established Fields," *World Petroleum* 473 August, 1935.
3. Yuster, S. T., and Calhoun, J. C., Jr., "Pressure Parting of Formations in Water Flood Operations," *The Oil Weekly* March 12 and March 19, 1945.
4. Dickey, Parke A., and Andresen, Kurt H., "The Behavior of Water Input Wells," *Drilling and Production Practice* 34 (1945).
5. Clark, J. B., "A Hydraulic Process for Increasing the Productivity of Wells," *Petroleum Development and Technology* 186, 1 (1949).
6. Clark, J. B., Fast, C. R., and Howard, G. C., "A Multiple-Fracturing Process for Increasing Productivity of Wells," *Drilling and Production Practice* 104 (1952).
7. Hassebrock, W. E., Stegelman, Arthur J., and Westbrook, S. S. S., "Progress in Sand-Oil Fracturing Treatments," *Drilling and Production Practice* 212 (1954).
8. Reynolds, Jack J., Bocquet, Phillip E., and Clark, Roscoe C., Jr., "A Method of Creating Vertical Hydraulic Fractures," *Drilling and Production Practice* 206 (1954).
9. Maly, Joe W., and Morton, Tom E., "Selection and Evaluation of Wells for Hydrafrac Treatment," *Oil and Gas Journal* 126 May 3, 1951.
10. Clark, R. C., Freedman, H. G., Bolstead, J. H., and Coffer, H. F., "Application of Hydraulic Fracturing to the Stimulation of Oil and Gas Production," *Drilling and Production Practice* 113 (1953).
11. McHugh, Jerome P., "112,000 Extra Barrels of Oil in 11 Months," *Oil and Gas Journal* 104 March 7, 1955.

★ ★ ★

OTIS PERMANENT COMPLETIONS

It was reported in the trade press recently that an operator in South Louisiana saved an average of 34 hours' rig time alone for each permanently-completed well. The tubing and wellhead are installed only once in a permanent completion — then the rig can be moved off. Perforating, testing, and placing the well on production are performed with wire line equipment at considerable savings over conventional methods. Heavy pipe-handling equipment normally used for workover operations is eliminated. And most significant about permanent completions is the number of *different* operations which can be performed *without a rig or workover unit:*

Squeeze-cementing and acidizing • Perforating casing below tubing • Plugback jobs
Sand bailing • Bottom-hole pressure tests and formation fluids sampling
Running sub-surface flow meters • Choice of fluid in the well bore when perforating
Testing stringer sands • Dry-testing cement jobs with tubing and packer in place
Radioactivity logging through tubing • And many others — all of which reduce workover time and costs, provide safer operations, and make a better producer.

Otis is the industry's recognized authority on wire line services and equipment for permanent completions. If you would like to have more information on the flexibility and operating advantages of permanently-completed wells, call your nearest Otis office. You will find them anxious to help you, and you will be impressed with the complete and competent information they will give you.

OTIS PRESSURE CONTROL, INC.
Branches Throughout the Oil Country

Tug tows "Mr. George" to the vicinity of a drilling rig and cuts loose.

P 422.914

Ship That Moves Sideways

as well as forward and backward delivers mud to offshore rigs

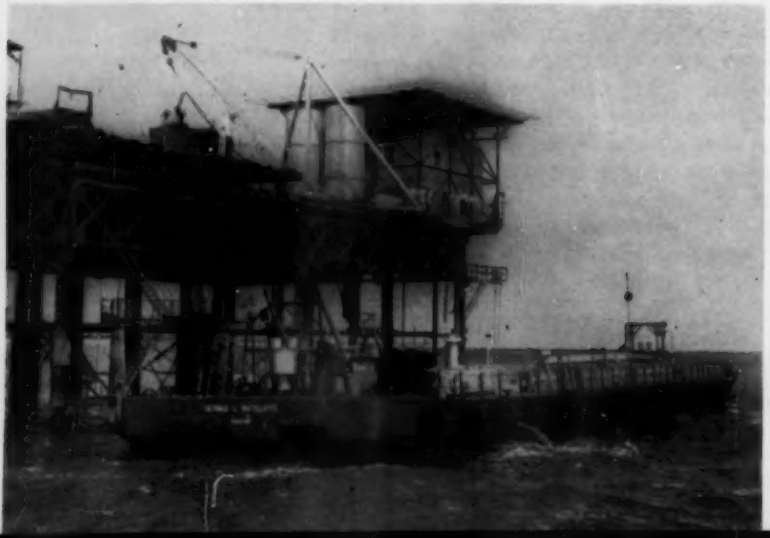
EVER hear of a ship that can turn round and round in the same spot? That's what "Mr. George" can do if the need for this particular maneuver ever arose. Not only that, "Mr. George" can make a forward and reverse speed of six knots and move sideways at about the same clip.

In reality, "Mr. George" is neither ship nor barge, but a combination of both. And it has so many novel and ingeneous features that when you visit it you keep wondering why you didn't think of some of them yourself.

This unique craft is Baroid's drilling mud delivery vessel. Officially it bears the name, "George L. Ratcliffe," and measures 196 ft long, 42 ft wide and 12 ft deep. Its payload is 1500 tons, and it is equipped to carry 1000 tons of bulk mud, 100 tons of diesel fuel and 600 tons of water. There is storage space for bagged mud materials.

Here's the way the vessel works. An ocean-going tug tows it to the vicinity of the offshore rig, and cuts loose, leaving "Mr. George" to go it alone. In the pilot-house, the barge's skipper pushes a button and propellers — both fore and aft — push down into the water 4½ ft below the bottom of the hull, and "Mr. George" becomes a ship.

"Mr. George" maneuvers sideways, forward and backward to move up to the rig and maintain position. Propulsion units, located fore and aft that can turn 360 degrees directionally, make this possible.



In effect, the two propeller drives resemble outboard motors. They can each turn 360 degrees directionally and both their direction and speed can be remotely controlled from the pilot house. And this control means a lot when "Mr. George" makes its final approach to a drilling rig in rough water.

This final approach involves the use of two systems. Using the first system, one or both of the two 6000 lb cruiser anchors located fore and aft of the vessel are dropped. Each anchor is handled by a power winch capable of a 50,000 lb line pull. Using the second system, the multi-speed propulsion units fore and aft are used to come into final position and then hold this position while deliveries are made. These electrically-powered units drive 52-in. diameter by 30-in. pitch propellers at speeds up to 352 rpm. Normally one propulsion unit is set to counteract the current and the other to hold the anchor lines in the proper position.

When bulk mud is delivered, the rig crane picks up a heavy duty 4-in. rubber hose and puts into the rig bulk tanks. Actual delivery then begins and the dry bulk Baroid is pneumatically pumped to the rig storage. (This system is much like the Navy method of refueling at sea.) Delivery of bulk Baroid is in batches of 2500 lb and a weight ticket is printed for each batch.

All equipment aboard is operated by power generated by three diesel-electric units capable of 685 KW output. The propulsion units will operate on any engine-generator combination.

Safety is one of the outstanding features of the "Mr. George." The diesel-electric power system reduces fire and explosion hazard to a minimum. The anchoring and propulsion systems are designed to give maximum safety to the operator's personnel, rig, structure and tenders at all times. Safety to delivery and operator's equipment, reliability of delivery, accuracy of weighing and time to get from one location to another have all been planned to give the best possible service in the safest manner.

The large mud stock, which makes the vessel a floating warehouse will reduce the hazard of offshore drilling and save operating time because the ready availability of this large mud stock will assist in controlling high-pressure wells.

Baroid Division's new Marine Terminal, now under construction on the New Orleans Industrial Canal will be home base for "Mr. George." Besides docking and transshipping facilities, this terminal will have the largest mud warehousing facilities in the country. The warehouse will be backed up by a plant for manufacturing the product Baroid from both domestic and imported barite ores. ★ ★ ★

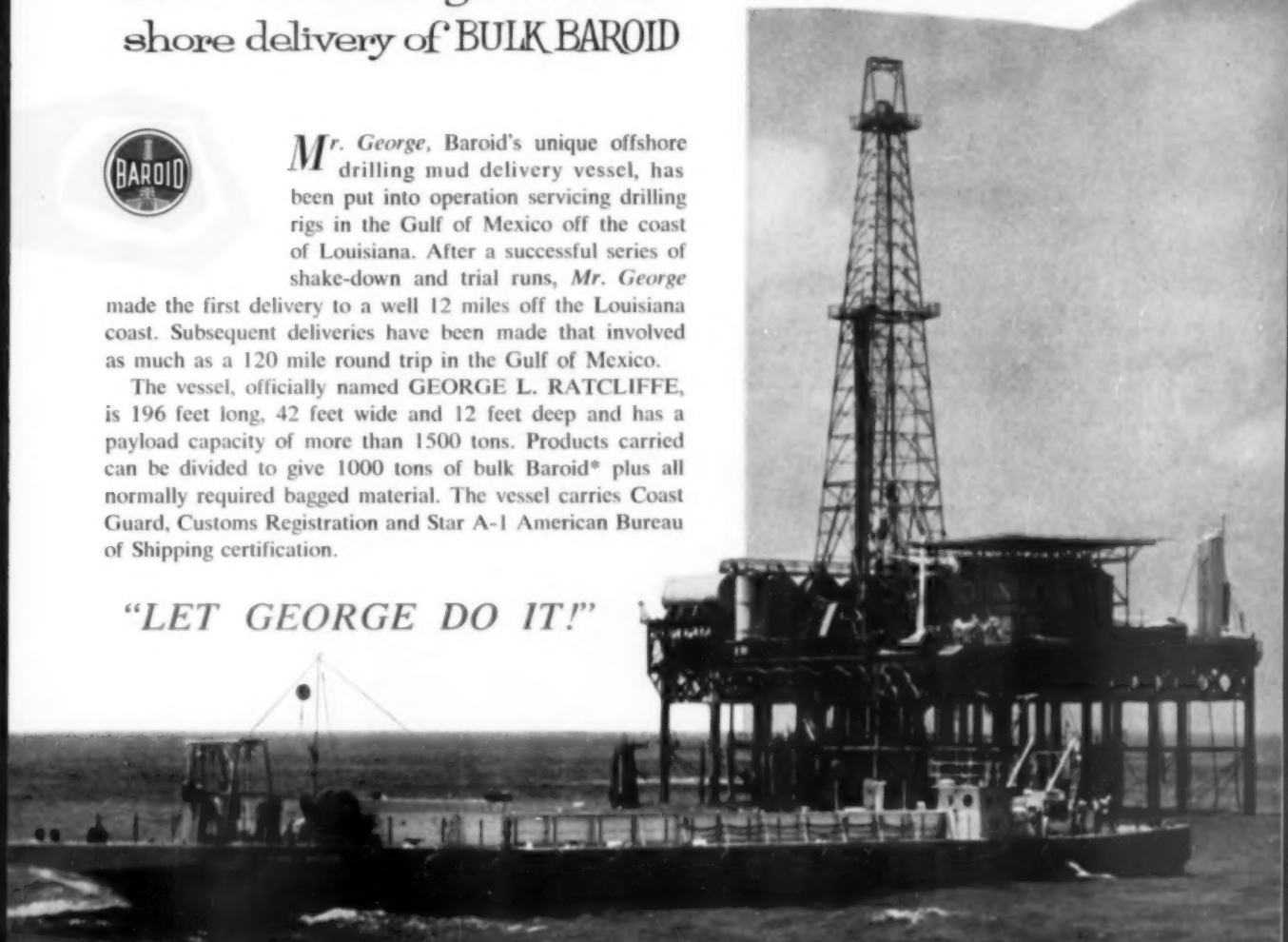
Mr. GEORGE now in service

First vessel designed for offshore delivery of BULK BAROID

Mr. George, Baroid's unique offshore drilling mud delivery vessel, has been put into operation servicing drilling rigs in the Gulf of Mexico off the coast of Louisiana. After a successful series of shake-down and trial runs, *Mr. George* made the first delivery to a well 12 miles off the Louisiana coast. Subsequent deliveries have been made that involved as much as a 120 mile round trip in the Gulf of Mexico.

The vessel, officially named GEORGE L. RATCLIFFE, is 196 feet long, 42 feet wide and 12 feet deep and has a payload capacity of more than 1500 tons. Products carried can be divided to give 1000 tons of bulk Baroid* plus all normally required bagged material. The vessel carries Coast Guard, Customs Registration and Star A-1 American Bureau of Shipping certification.

"LET GEORGE DO IT!"

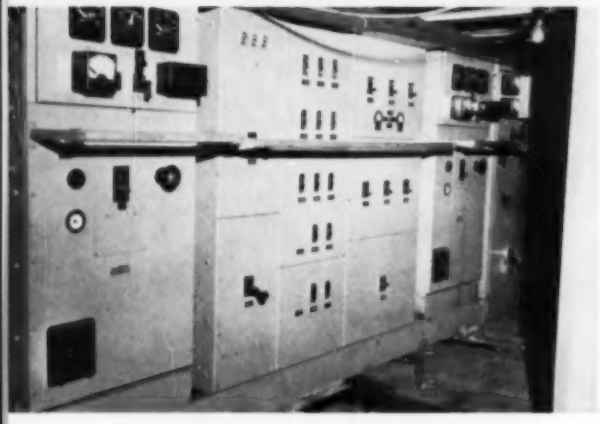


BAROID

BAROID DIVISION • NATIONAL LEAD CO.
Main Office: P. O. Box 1675, Houston 1, Texas
New Orleans Area Office: 918 Richards Bldg.

*Registered Trademark of Baroid Division, National Lead Co.

The "Mr. George" is towed to offshore locations by a sea-going tug. Upon arrival operating personnel are transferred to the "Mr. George," lines are cast off, the final approach is made to the rig and actual delivery of the mud commences.



The nerve center of "Mr. George" consists of the generator and distribution switchboards. The vessel's equipment is all electrically powered and the generators are equipped with automatic synchronizers. This photo made during "Mr. George's" construction period gives an idea of the size of switchboard.

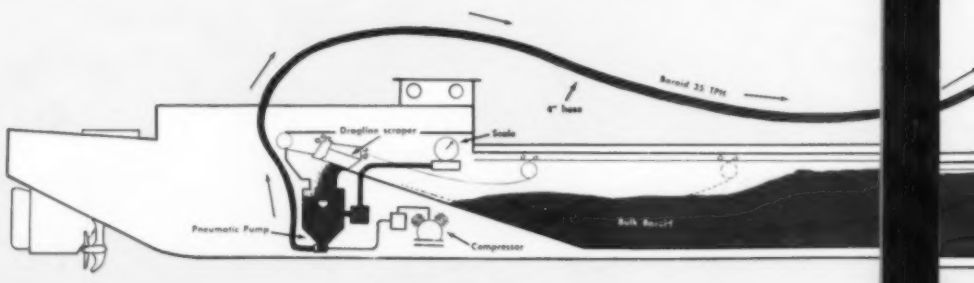
Mr. George is towed to the vicinity of the rig by a deep-sea tug equipped with radar, ship-to-ship and multi-channel marine radios. The *Mr. George* carries ship-to-ship and FM radios, thus communications can be maintained between the tug, rig, *Mr. George* and land bases at all times.

The tug is manned by experienced deep-sea operating personnel. The *Mr. George* is under the command of Captains D. A. Smith and W. F. Nesser; both are licensed ship masters with wide experience in deep-sea operations.

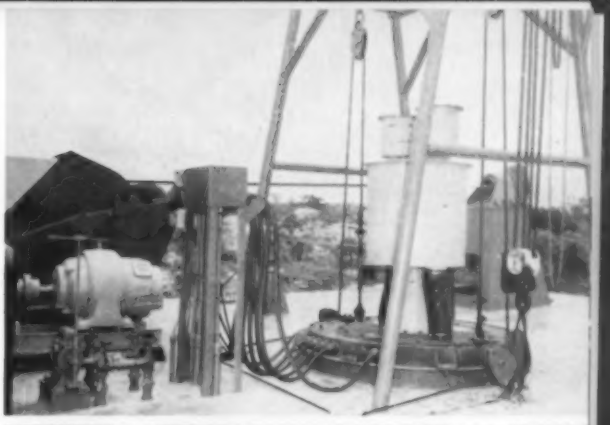
Upon approaching the rig the tug casts off its lines and the unique features of *Mr. George* are used to make the final approach, maintain position and make the mud delivery. Final approach involves the use of two systems. Using the first system, one or both of the two 6000-pound cruiser anchors located fore and aft of the vessel is dropped. Each anchor line is handled by a power winch capable of a 50,000-pound line pull. Using the second system, the multi-speed propulsion units located fore and aft are used to come into final position and then hold this position while deliveries are made. These propulsion units are driven by electric motors wound to give four speeds forward and three speeds reverse. Propellers are 54-inch diameter by 30-inch pitch and their rotational speed can be varied up to 352 rpm. The unique feature of the propulsion units is that they can be independently rotated through a full 360 degrees; therefore each propeller can push or pull in any direction. Normally one propulsion unit is set to counteract the current and the other to hold the anchor lines in the proper position.

This view looks forward into bulk mud hopper of "Mr. George." The hopper can carry a 1,000 ton payload of dry bulk Baroid. Bulk mud is gathered by a one cubic yard Sauerman scraper and pulled into position for filling the pneumatic pump hopper.

Schematic Flow Diagram showing the movement of the bulk Baroid mud from the hold of the delivery vessel through the pneumatic pump and delivery hose to rig storage tanks.



"Mr. George's" powerful propulsion units are lowered when the vessel arrives at location. These units enable the vessel to make the final approach under its own power. Each propulsion unit, one fore and one aft, has four speeds forward, three speeds reverse and can be rotated through 360 degrees.



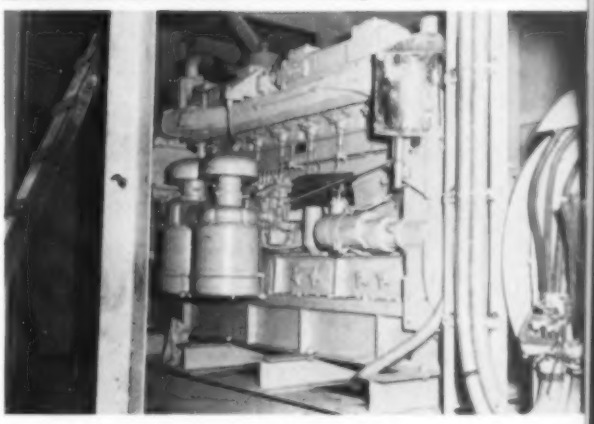
When bulk Baroid is delivered a heavy duty four-inch I.D. rubber hose is picked up by the rig crane and the end of the hose put into the rig bulk tanks. Actual delivery then begins and the dry bulk Baroid is pneumatically pumped to the rig storage. This system is much like the Navy method of refueling at sea. Delivery of bulk Baroid is in batches of 2500 pounds, and the automatic weighing equipment prints a weight ticket for each batch.

When palletized products are delivered, the rig crane drops its line with pallet hooks or sling attached and hoists the material aboard in the conventional manner.

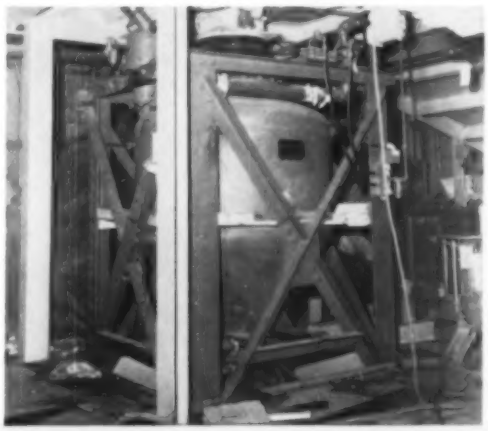
All equipment aboard *Mr. George* is operated electrically. Power is generated by diesel engine prime movers. The three engines and generators are capable of 685 KW output. The propulsion units will operate on any engine-generator combination.

Safety is one of the outstanding features of the *Mr. George*. The diesel-electric power system reduces fire and explosion hazard to a minimum. The anchoring and propulsion systems are designed to give maximum safety to the operator's personnel, rig, structure and tenders at all times. Safety to delivery and operator's equipment, reliability of delivery, accuracy of weighing, and time to get from one location to another have all been planned to give the best possible service in the safest manner.

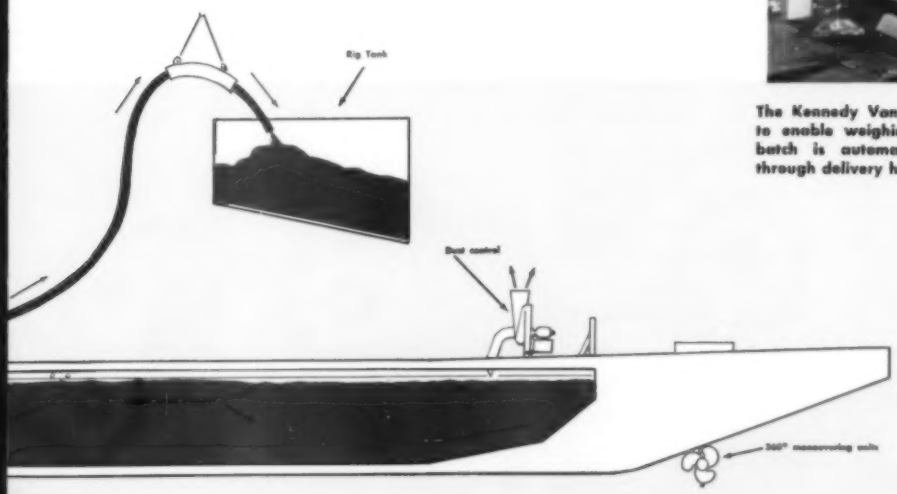
The large mud stock, which makes the vessel a floating warehouse, will reduce the hazard of offshore drilling and save operating time because the ready availability of this large mud stock will assist in controlling high-pressure wells.



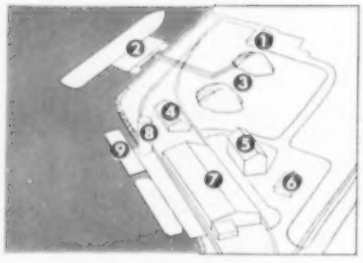
All the operating equipment on "Mr. George" is electrically powered. Two Buda 250-KW diesel-electric generators furnish the electric power for operating the engines, anchor winches, dragline, pneumatic pump and all auxiliary machinery.



The Kennedy Van Saun pump is mounted in special flexures to enable weighing bulk mud in 2,500-pound batches. Each batch is automatically ticketed and pneumatically blown through delivery hose to bulk storage tanks on the offshore rig.



BAROID



1. Seaplane hangar and parking area
2. Crane barge unloading ore vessel
3. Ore piles
4. Carpenter, bulk can repair and machine shop
5. Mill building
6. Office building
7. Warehouse
8. Silo storage for "Mr. George"
9. "Mr. George" — delivery vessel

Baroid's new marine terminal

Baroid Division's new Marine Terminal, now under construction on the New Orleans Industrial Canal, will be home base for *Mr. George*. Besides docking and trans-shipping facilities, this terminal will have the largest mud warehousing facilities in the country. The warehouse will be backed up by a plant for manufacturing the product Baroid from both domestic and imported barite ores.

Facilities at Berwick, Louisiana, will also be utilized for keeping *Mr. George* supplied with mud.

Exhaustive testing and the recently completed series of actual deliveries have demonstrated that *Mr. George* is the safest, fastest, most convenient method of offshore mud delivery available.

BAROID

BAROID DIVISION • NATIONAL LEAD CO.
Main Office: P. O. Box 1675, Houston 1, Texas
New Orleans Area Office: 918 Richards Bldg.

BAROID

Here is the best way to hold costs down: Plan every detail of a proposed workover job; see to it, that everyone connected with the job gets the plans and understands his responsibilities

SPECIAL Well Workover FEATURE

Planning and Supervising Workover Jobs

J. N. Pedersen, *The California Company*

SMOOTH workover jobs don't just happen — they are planned.

The importance of planning cannot be overstressed. During recent years, workover techniques have become more and more complicated and the costs of most individual remedial operations have risen. Yet during the same period, the price of crude has not advanced proportionately; and only careful and precise planning keeps a workover job from pricing itself out of the picture in many instances.

This does not mean that the planning of each individual workover operation should become a major engineering project. The experiential background of workover jobs in a particular field certainly forms the basis for more or less standard procedures for doing many remedial jobs. Yet, before any workover job starts, it should be carefully planned and the essence of this planning reduced to written form. Loose ends should be tied down, and the responsibility for every phase of the job should be delegated.

Assuming that the desirability of working over a well has been determined, the initial planning should be along these lines:

1. **The present status of the well should be carefully noted.**
2. **The economic justification of the proposed job should be analyzed.** (Of course, there are reasons other than economic for working over a well. To name a few: there are lease inequities to be remedied; competitive reservoir drainage to consider; and the conservation of reservoir energy to maintain.)
3. **The step-by-step plan of the workover should be outlined.**
4. **A detailed cost estimate of the job should be prepared.**

Several purposes are served by summarizing the above information in a written **"Job Proposal"** in the order listed above. This proposal forms the basis for management approval (or disapproval) of expenditures for the job. Once approved, it becomes the master plan of the job and is followed from start to finish.

Present Well Status. This section of the **"Job Proposal"** briefly presents the physical condition of the well. Where previous workovers have been performed, only information that would pertain to the proposed job need be included. Here are some major facts which should be included: **completion date, casing and tubing description, presently open perforated interval, packer description and setting depth, initial producing status (or initial producing status following previous workover), present producing status (or producing status immediately before the well went off production), cumulative production following previous workover and cumulative production of the well.**

Before this section is prepared, the tour reports of initial completion and any previous workover jobs should be studied carefully. Even though this seems more or less routine, it helps eliminate surprises during the actual workover job. And most trouble in the oil field starts with a "surprise." To cite a hypothetical case, suppose a liner is hung in a well and the weight per foot of the liner pipe is not recorded on the tour report, or not checked when planning the workover. The production packer might then be dressed for the wrong weight pipe and a costly misrun would result. Such oversights can be eliminated by careful and thorough planning.

Discussion and Economic Justification. This section of the job proposal reviews factual data used in the analysis of the problem, recommends a solution and presents the economic justification for the job. It answers the questions on *why*, *what* and *when*. *Why* should the well be worked over? Is it really a problem well?, etc. *What* should be done to the well? (Of course, in most instances, all of the reasoning behind the answer to this question will not be given because the basis may be a lengthy reservoir or field study, etc.) *When* will the job pay out? After all, the number one reason for a company doing business is to make a profit, and this report should carefully analyze the chances of making the workover job a profitable one. This section should include the expected rate of production, the expected recovery, the length of the payout period and the expected productive life of the well as a result of the workover. Payout should be calculated using net value of oil to the operator, i.e., after royalties, taxes and lifting costs.

Plan of Workover Procedure. An important aid in coordinating the workover is the written workover procedure. This is usually a general description of the steps to be followed in the workover. The amount of detail to be included would depend on whether routine or special procedures are

The Author

J. N. Pedersen has been with The California Company since 1944. At the present time he is the division petroleum engineer of the company's North Louisiana-Mississippi division. Prior to this he had assignments in South Louisiana, Mississippi and Venezuela. He graduated from Louisiana State University with a BS in petroleum engineering.

the answer to hypothesis . . . a

Johnston test

Question: How much oil and gas in the reservoir?

Question: Is "displaced" oil present under the lease?

Answering the above questions will require a great deal of information—with formation pressures playing the all-important part. Obviously, *accurate* formation pressures must be obtained if either answer is to be anything more than a guess.

Additional drilling or a costly well completion could supply the answer, *BUT* the economical way is a Johnston Drill Stem Test.

The Johnston Tension Type Pressure Recorder used in conjunction with the Johnston Drill Stem Tester is the most valuable tool available to the reservoir engineer and exploration geologist for primary evaluation. By far the most accurate pressure recorder used in drill stem testing (5/100 of 1%), the Johnston Type "T" was designed for accuracy and dependability under the most severe conditions.

Why not get "tops in testing"—call Johnston, drill stem testing specialists PLUS experience and a real desire to serve you!

JOHNSTON TESTERS

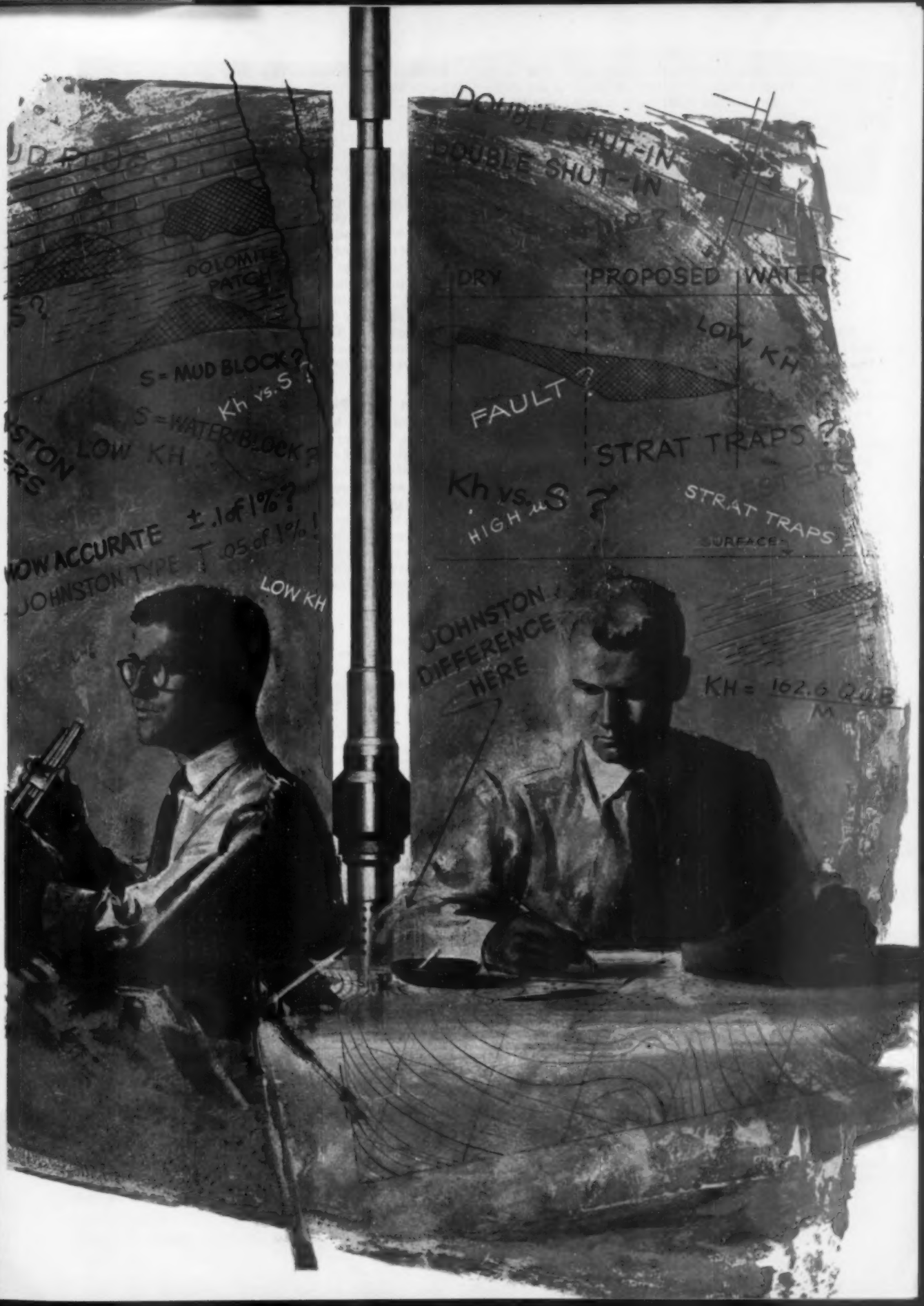
first in drill **stem testing**

A Subsidiary of Schlumberger Well Surveying Corporation

P. O. BOX 98,

HOUSTON, TEXAS

LOS ANGELES, CALIF. • CALGARY, CAN.


DOLOMITE PATCH
S = MUD BLOCK?
Kh vs. S ?
S = WATER BLOCK?
LOW KH
HOW ACCURATE ± .1 of 1%?
JOHNSTON TYPE ± .05 of 1%!
LOW KH
DOUBLE SHUT-IN
DRY
PROPOSED
WATER
LOW KH
FAULT ?
STRAT TRAPS ?
Kh vs. μS ?
HIGH
STRAT TRAPS
SURFACE
JOHNSTON DIFFERENCE HERE
KH = 162.6 Q μ B / M

to be followed. Such specific information as interval to be squeezed, proposed perforation interval, and drill out depth should always be included. Here is an example of a typical plan of this kind:

(1) Move in rig and rig up.
(2) Mix mud and kill well.
(3) Unseat packer and pull tubing.
Circulate around with mud before pulling tubing.
(4) Squeeze perforations 9082-9124.
(5) Drill out below shoe to 9162.
(6) Run casing scraper.
(7) Run electric log in open hole.
(8) Set production packer on wire line.
(9) Tube well with gas lift valves.
(10) Gas lift in and release rig.

When the job proposal has been approved, it is good practice to furnish the field foreman and the tool pusher copies of this work procedure. Special instructions to either the foreman or tool pusher may be added to their respective copies. The following is an example of additional instructions to the field foreman:

The estimated time for workover is 10 days.

The following items will be needed on location before the job starts:

(1) Fuel for rig.
(2) Fresh water to mix mud.
(3) Small fresh water tank for water to squeeze with.
(4) 10 jts. 2½-in. EUE J-55 tubing.

The following will be needed before the job is through:

(1) Gas lift line.
(2) Intermitter and heat exchanger.

If there is no pit at the well, one should be dug as the fluid now in the well will have to be displaced. Also, workover mud will have to be disposed of at the end of the job.

Description	Labor, Services & Transportation	Material	Total
Intangible Costs			
Surface:			
Location	$ 100	$	$
Move in Rig	600		
Rigging Up & Down	800		
Clean Up	100		1,600
Subsurface:			
Contract Drilling	4,000		4,000
Rentals & Services:			
Howco	232		
Gamma Log	458		
Wireline:			
Bridge Plug	400		
Packer Setting	380		
Electric Log	610		
Casing Scraper	110		
Junk Basket	170		
Tubing Testing	600		3,160
Drilling Fluids			
Water Hauling	300		300
Fuel		100	100
Cementing	446	150	596
Other Subsurface Expense			
Two 4-5/8" Rock Bits		210	
Supplies		100	
Transportation	100		
CI Bridge Plug		165	
Magnesium Retainer		247	
Supervisory	160		982
Tangible Costs			
Subsurface:			
Producing Equipment			
Production Packer		588	
Gas Lift Mandrels & Dummies		1,490	2,078
Well Pipe			
Tubing	$	$ 100	$ 100
	Total		$12,716
	GPS		127
	OH		76
	GRAND TOTAL		$12,919

FIG. 1. **Breakdown of costs** of the proposed workover of Joe Doaks No. 1. The cost of a workover should nearly always run within 5 per cent of the estimate. When unexpected trouble makes the job a problem workover, it is sometimes best to move off the job and make new plans rather than let costs snowball.

Detail of Cost Estimate. This detail should include all anticipated workover costs with a breakdown between tangible and intangible costs which in turn would include a breakdown between surface and sub-surface cost. It is advisable to develop a standard form for this estimate sheet. The form should list by the above mentioned categories all anticipated costs.

One of the greatest aids in this respect is to prepare a cost estimating book. This book is primarily a compilation of price lists of all the service and supply companies doing business in the area. The companies are glad to supply this material at no cost. With a working knowledge of the equipment and procedure to be used, it is usually possible to estimate the total cost of a job within five per cent.

Fig. 1 is a sample work sheet for estimating the cost of a workover. This estimate of costs in turn is included with the job proposal in the form shown in Fig. 2. When the job proposal is approved, the estimating work sheet is used by the engineer or company representative on the job to keep a current record of costs incurred as the job progresses.

Problem Well Planning

Too much can't be said for planning before the workover job begins, but there also comes a time for planning during the job — especially if the well being worked over turns out to be a problem workover job. When a prearranged procedure does not work, there is a tendency to hastily improvise an alternate plan. Generally speaking, this is good oil field practice, but it can lead to the state where the workover job is supervising the supervisors instead of the other way around.

At this point the best remedial step is to shut the job down; perhaps even move the rig off the location. Then lay deliberate and careful plans for subsequent action. This course of action

THE CALIFORNIA COMPANY

REQUEST FOR WELL APPROPRIATION CC-204 Rev. 1 — No. Any Code #231

☐ DRILLING ☐ DEEPENING ☒ REDRILLING

DIVISION North Louisiana-Mississippi — AMOUNT (CALCO'S SHARE) $10,505

FIELD Any — WELL Joe Doaks #1 — DATE February 16, 1956

WE RECOMMEND Squeezing off the existing perforations, drilling out to the oil-water contact and completing in open hole.

ESTIMATE

Labor, Services & Transportation	$9,406	
Materials	3,310	
TOTAL FIELD ESTIMATE		$12,716
General Field Expense		127
Overhead		76
TOTAL ESTIMATED COST OF PROJECT		$12,919

REASONS FOR EXPENDITURE

Joe Doaks #1 is shut in because of its high GOR. We believe that dry gas is breaking in through the upper set of perforations and therefore the GOR can be lowered substantially by drilling out to the oil-water contact and completing in open hole. There is an estimated 50,000 barrels of oil to be recovered as a result of this workover.

PARTICIPATIONS & AUTHORIZATIONS	TOTAL	PARTNER'S SHARE*	CALCO'S SHARE
Original Appropriation	$12,919	$2,414	$10,505
Previous Supplements			
This Supplement - No. ___			
TOTAL	$12,919	$2,414	$10,505

* 19 $ of Total Field Estimate

BUDGET DATA: Budget Period First Half 1956 — Category Relating to existing wells

Amount Authorized ___ Amount This Appropriation To Be Capitalized $1,683

Title Clearance ___ Geological Letter ___ Conforms With Spacing Rules ___

Estimated Payout Is .1T Years Or 2 Years Useful Life At 55 % Taxes At 150BOPD Rate

Rate of Return On Outstanding Investment ___ %

RECOMMENDED — APPROVED

___ Date ___ Date

___ Date ___ Date

___ Date ___ Date

CC-204 Rev. 1

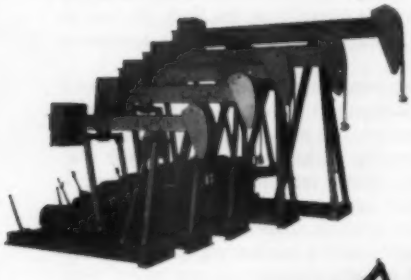
FIG. 2. **Job Proposal form's** first page includes general information and a summary of plans for working over Joe Doaks No. 1. More detailed plans are circulated to everyone who will be connected with the workover; responsibilities are clearly defined and delegated.

LUFKIN Presents...

THE ABC's OF ECONOMICAL PRODUCTION

A AIR BALANCED UNITS

For compactness, light weight and ease of installation. Available in sizes ranging from 80,000 in. lbs. peak torque and 19,000 lbs. polished rod capacity to the mighty A-912DA-192-42 with 912,000 in. lbs. peak torque, 192 inch stroke and 42,000 lbs. polished rod capacity.



B BEAM BALANCED UNITS

Where economy is an important factor and dependability a prime consideration. Sizes from the B-10D-20-4 with 10,000 in. lbs. peak torque and 4,000 lbs. polished rod capacity to the B-57D-42-10.5A with 57,000 lbs. peak torque and 10,500 lbs. polished rod capacity.

C CRANK BALANCED UNITS

The all purpose unit known the world over for its ruggedness, trouble-free performance, and low cost maintenance. Sizes from the C-25D-24-6 with 25,000 in. lbs. peak torque and 6,000 lbs. polished rod capacity to the C-912DA-168-30 with 912,000 in. lbs. peak torque and 30,000 lbs. polished rod capacity.

Plus... LONG STROKE HYDRAULIC UNITS

For deeper wells and heavier fluid loads where high rod stresses are encountered. Rod life is greatly increased by this unit's slow, cushioned reversals and uniform polished rod velocity which avoids high peak loads. Available in 35,000 lbs. polished rod capacity and 20 ft., 25 ft., and 30 ft. stroke lengths.

Lufkin **FOUNDRY & MACHINE COMPANY**

LUFKIN, TEXAS

Branch Sales and Service: Houston • Dallas • New York • Tulsa • Los Angeles • Seminole • Oklahoma City • Corpus Christi • Odessa Kilgore • Wichita Falls • Casper, Wyoming • Great Bend, Kansas • Effingham, Illinois • Duncan, Oklahoma Brookhaven, Mississippi • El Dorado, Arkansas

Lufkin equipment in Canada is handled by THE LUFKIN MACHINE CO., LTD., 9950 65th Avenue, Edmonton, Alberta, Canada 3913 18th Avenue, Regina, Saskatchewan, Canada

often keeps a workover job from running away so far as cost is concerned.

Preparation for the Workover Job

There are dozens of details that must be attended to before the workover job starts. A rig must be selected that matches the job; the location must be prepared; materials must be procured; easements for fuel or water lines must be obtained; and the service companies must be alerted if special equipment will be needed.

The key to this phase of the operation is company organization. The responsibility for handling these and the many other details must be delegated. Of course, this does not mean that a new set of orders must be "cut" for each individual well, because the field organization has already been set up to handle workover jobs. Only new and unusual conditions warrant changes in organizational duties.

Selecting the rig to match the job. There is no hard and fast rule for selecting a workover rig. One suitable for a specific job in one field may not be at all suitable for the same job in another field. However, there are a few general rules that should usually be followed. For one thing, the rig should be able to pull to the strength of the tubing string in the hole, because the first hurdle in the workover job is usually to pull the production packer. The pumps should be sized to produce sufficient volume to remove cuttings from the hole, and this will depend strongly on the type of workover fluid to be used on the job.

Actually, the most important consideration is to outline clearly in the contract with the rig owner just what he is to furnish and what the company is to furnish. If the company furnishes such items as roads, pits, rig fuel, water lines, mud, cement, etc., special tools, tubing, and necessary tools for reworking the well, they should be specified in the contract. If the contractor is to furnish blowout preventers, sand line and reel, power tongs, etc., this too should be clearly set forth in the contract. The blowout preventer equipment specifications should be carefully described; a sketch of the desired hookup may be attached to the contract. This minimizes the chances of slip-ups and delays.

Other things to be included in the contract agreement are: (1) maximum allowances for transportation, rigging-up and rigging-down; (2) the hourly rate and the standby rate; (3) the hourly rate and limit of hours for making repairs to the rig on the job.

The clarity of the understanding with the contractor can actually speed the workover job.

Clearances. One of the first items requiring attention is to prepare proper forms for state boards if the workover is to be other than mechanical repairs, i.e., completing in a different reservoir, etc.

Also, the land owner should be notified that a workover job will soon be underway and if water lines, gas lines, etc. are to be laid across his land (and the lands of others) easements should be obtained.

Preparation of the location. Company men should make a detailed check of the location in light of the workover job to be done. Here are some of the more important items that should be handled before the workover rig moves to the site:

1. Connecting lines — water or fuel — should be laid.
2. The location should be cleared.
3. If a burn pit is needed, it should be dug and fenced (thoroughbred cattle have a tendency to fall into pits).
4. Mud pits should be dug if tanks are not to be used. They, too, should be fenced.
5. Preparations should be made for cement, mud, and chemical storage — usually a section is boarded off and tarpaulins are obtained for weather protection.
6. Tanks for workover fluids should be moved to the site.
7. Workover fluids such as weathered crude, salt water or mud should be on hand at the proper time.

Materials. All materials that will be used in the workover job should be scheduled to arrive early at the location. Tubing, packers, bridge plugs, cement retainers, gas-lift valves, should be purchased, checked and made ready for the job.

Special service equipment and materials. Service companies should be alerted well in advance if special tools or equipment will be needed on the job. As the job progresses each service company should be alerted in time to arrive at the job before their services are needed.

WORKOVER COST CONTROL

WELL: Joe Doak #1

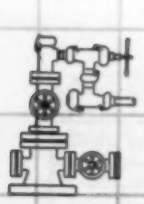
Description	Estimated	Actually spent thru date indicated	TOTAL
INTANGIBLE COSTS			
Surface:			
Road Maintenance			
Location	100		
Mud & Water Hauling	200		
Clean Up	100		
Moving In Rig	400		
Rigging Up & Down	600		
Subsurface:			
Contract Drilling	4000		
Rentals & Services			
Howco	232		
Fishing Tool Operator			
Fishing Tool Rental			
Dowell Services			
Baker Service			
Retrievable Tool Rental			
Junk Basket	190		
Casing Scraper	110		
Production Perforations			
Squeeze Perforations			
Wire Line Services	780		
Dia-Log Services			
Radioactivity Survey	658		
Drill Collar Rental			
Electric Log	610		
Tubing Testing	600		
Fuel	100		
Drilling Fluids			
Gels & Clays			
Weight Materials			
Chemicals			
Salt Kem Mud			
Cementing	446		
Squeeze	180		
Plugback			
Casing Repair			
Other Subsurface Expense			
Rock Bits	210		
Supervisory	160		
Junk Pusher			
Supplies	100		
Transportation	100		
Retainers			
Welding			
Cement Retainer	347		
Cast Iron Bridge Plug	166		
TANGIBLE COSTS			
Surface:			
Flowline			
Xmas Tree			
Gas Lift Line			
Intermitter			
Subsurface:			
Producing Equipment			
Production Packer	588		
Tbg. Hanger & Stick Jt.			
G. L. Valves	1490		
Well Pipe			
Tubing	180		
Safety Joint			
TOTAL	12 716		
OPX	187		
OH	76		
GRAND TOTAL	12 919		

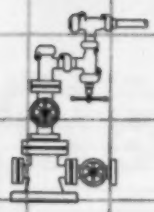
FIG. 3. **Workover cost control sheet** for the field. Note that the estimate is shown and day-to-day costs are tallied as the work progresses.

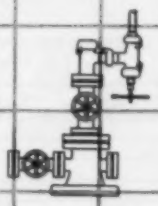
Supervision of the Job

The plan for the workover job is not secret. The contractor and his tool pusher get copies of the workover procedure in advance, as do all interested company men. This is highly important from the standpoint of saving money.

Supervision of rig equipment. Where organization is important, the chain of command is best. This should be true of company forces and at the same time true of company forces' dealings with the contractor. For the most part, all orders from the company to the contractor go through one man to the contractor's tool pusher. This enables the contractor to get optimum performance out of his equipment and men and the increased efficiency is of tangible benefit to the company.





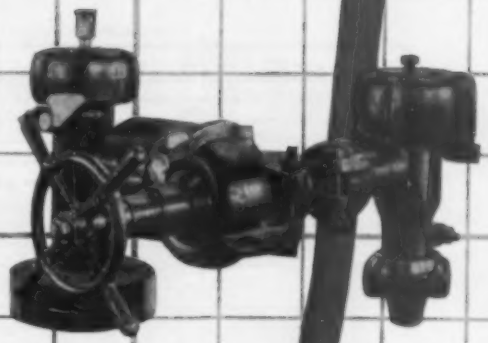


UNIBOLT
flow manifolds

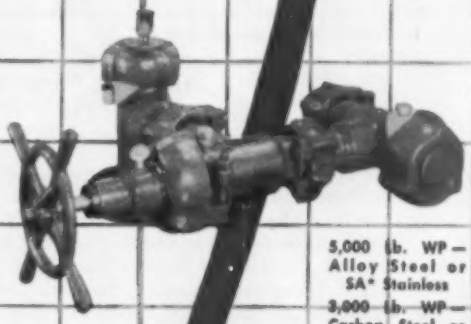
fit your pressures as well as your pocketbook

These are the Christmas tree manifolds that are custom-built to any operator's flow control needs, but at no premium in price. Unlike manifolds of fixed design, UNIBOLT permits complete flexibility in arrangement of its units. Components may have threaded, flanged or UNIBOLT connections. They may be of malleable, regular steel, alloy or SA* stainless, depending upon pressures and service. The chokes may be adjustable or positive with interchangeable flow-rated beans or X-beans. Tee type for single wing or cross type for double wing trees are available. Select exactly what you need for the well. Later on you may salvage the entire manifold as a unit or as individual parts for use elsewhere. By any yardstick, UNIBOLT Flow Manifolds give you far more desirable features . . . at a reasonable cost.

*Special Analysis

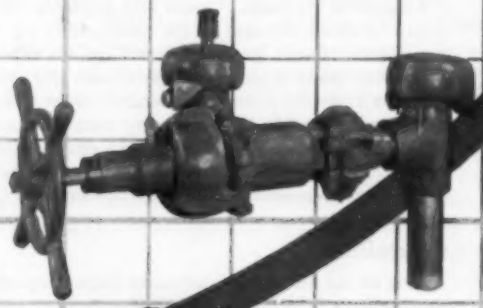


10,000 Lb. WP — Alloy Steel or SA* Stainless

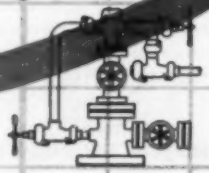


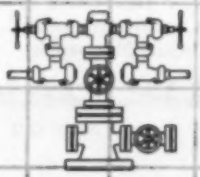
5,000 Lb. WP — Alloy Steel or SA* Stainless
3,000 Lb. WP — Carbon Steel or SA* Stainless

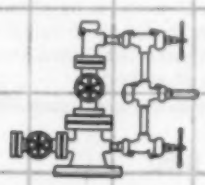
3,000 Lb. WP — Carbon Steel or SA* Stainless
5,000 Lb. WP — Alloy Steel or SA* Stainless



3,000 Lb. WP — Carbon Steel or SA* Stainless
5,000 Lb. WP — Alloy Steel or SA* Stainless







THORNHILL CRAVER CO.
P. O. BOX 1184 HOUSTON, TEXAS

THE CALIFORNIA COMPANY

"KEEP CURRENT-ON LOCATION" WELL Joe Dooks #1 DATE 7-11-56

REMOVED FROM WELL	CODE	FROM STOREHOUSE	CODE	PURCHASED	F.O. D.T.	INSTALLED IN WELL	CODE	BALANCE & DISPOSITION OF BALANCE	CODE
10 JTS 2" EUE 8RD N-80								ALL ITEMS REMOVED	
TBG (315.05')	D							FROM WELL LEFT ON	
1-2" EUE HOMCO SAFETY JT	E							LOCATION TO BE	
1-BAKER LOCATOR SUB	E							PICKED UP BY	
2-2" BAKER SEAL								ROUSTABOUT GANG	
NIPPLES	E								
1-2"x5½" BAKER									
MOD 415 D PACKER	E								
		10 JTS 2" EUE 8RD N-80				9 JTS 2" EUE 8RD N-80		1-JT 2" N-80 LEFT	
		TBG (317.21')	A			TBG (287.40')	A	ON LOCATION TO BE	
		10 SX CALGON				} ALL MUD USED		PICKED UP	A
		3 SX QUEBRACHO							
		42 SX GEL							
				1-2"x5½" BAKER		ALL ITEMS			
				MOD 415 D PACKER	2465	PURCHASED WERE			
				4-GOT TYPE D2-F		RUN IN WELL			
				GAS LIFT MANDRELS	2468				
				4-GOT TYPE "D" JR					
				VALVES & CHOKES	2468				
				45 SX MAGCOBEL	2467				

FIG. 4. **Keeping up with materials** saves money — and time too. This simple form is kept current on the job location.

Supervision of job procedure. Citing a typical major company operation, the responsibility for the overall supervision may stem from the area superintendent. Many of the tasks are in turn delegated to a lead engineer and to a field foreman. In most instances, the field foreman has charge of preparing the location, laying the connecting lines, etc. The lead engineer must arrange for materials that will be needed and in addition, it is his responsibility to see to it that service companies are on the job when needed. Also, he is responsible for preparing state board reports, etc.

Responsibility for tour reports. Other responsibilities of the engineer include verification of the accuracy of the contractor's tour reports. Complete and accurate tour reports are essential since these reports become a permanent part of the well history; and in event of another workover, they will furnish the primary source of information on the mechanical status of the well. The company furnishes tour report forms to the contractor and space is usually provided on this form for any remarks, etc., the engineer wishes to make.

Responsibility for measurements. The engineer or job supervisor is primarily responsible for measurements. But because of the critical nature of measurements on a job, the tool pusher is also requested to keep measurements. In addition, the engineer must verify measurements taken by service engineers.

Cost Control

Because most workover jobs are business ventures by and large, it is highly important that cost control be carefully watched. This control starts with the **"Job Proposal"** which becomes the approved expenditure proposal. Approvals are usually controlled by specified limits of authority. Minor well maintenance within a specified monetary limit may be approved by the field superintendent, whereas a major workover involving recompleting in another sand may require approval of top management. When a job runs over the estimate on the proposal form, a supplementary request for expenditure is usually made. Approval of supplements is usually controlled by the same established limits (original estimate plus supplement) of authority.

Day-to-day cost control during workover. But cost control is followed on a day-to-day basis in the field when the job is underway. The sample form in Fig. 1 provides for current posting of costs. This is usually kept by the engineer assigned to the job, and with this information he can anticipate and prepare supplementary requests as required. Note that the costs are broken down between tangible and intangible charges.

Material control. Most major oil companies use purchase orders for new material and material transfer tickets for moving material in and out of warehouses and from field to warehouse, etc. In fact, no material is moved without a written record being made.

Material control on the job. The current record of material on a workover job is kept on the accompanying form. Note that the form is set up so that the first three columns furnish a record of materials that come to the location (even though the column on the left shows material that is removed from the well itself.) The two right hand columns show the final disposition of the material, i.e., either it is installed in the well or it is left as a "balance." But even here, disposition of the balance is noted.

Control of services. The costs and other service charges are published and there is little chance for misunderstanding as to the cost of the service and the performance of the service.

Control of rig costs. Almost any probable combination of events affecting the cost of the contractor's rig is covered in the contract itself. But the job will go smoother and sometimes even faster if all the company men and the contractor's key men *know the contract*. Ignorance of the terms of the contract could possibly lead company men to incur extras that otherwise would not be charged. Too, chances for friction between contractor and company personnel is greatly lessened if the contract is understood by all concerned.

Conclusion

One of the most important tasks facing any oil company is to constantly improve its planning techniques and supervision of workovers. This can best be done through keeping careful records of workover jobs as they are done and then carefully analyzing the results after the workover has been completed.

* * *

New item on our stock list is in every National car!

Anything that helps to make driving safer gets special attention at National Supply. That's because we drive a lot to serve you. Our field men drive 700 vehicles more than 1,600,000 miles every month, or about 1 1/10 times around the world for each car, each year.

Early this year, as an extra precaution, we had safety belts installed in every National car. We've found them so worthy that we've added safety belts on the stock lists in some of our stores.

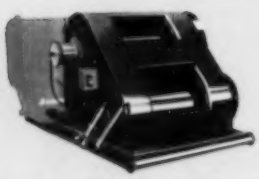
Is the safety belt an unusual item for oil field stores to stock? We don't think so. We believe in store inventories, tailored to area needs, that offer operators whatever they want in field equipment and supplies. As a result, some National stores stock snake bite kits. Some sell geiger counters, many sell detergents. Others have considerable marine equipment to serve offshore rigs. If you need a special item not in stock, we work fast to get it for you. And we always like to recommend products—like the safety belts—we use ourselves.

Your satisfaction with such National Supply store policies has made us the world's largest oil country supplier. While we're constantly looking for additional ways to improve our service, we trust you'll always tell us whenever and wherever we can serve you better.

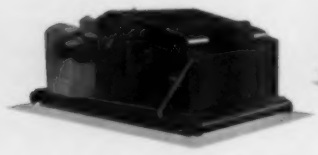
THE
NATIONAL SUPPLY
COMPANY

OPERATORS REPORT "MINIMUM

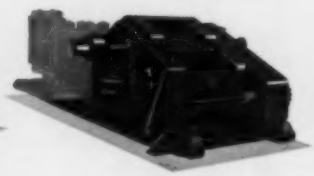
THERE'S A NATIONAL TRUCK-OR TRAILER-MOUNTED RIG TO SERVE EVERY OPERATOR'S NEED!



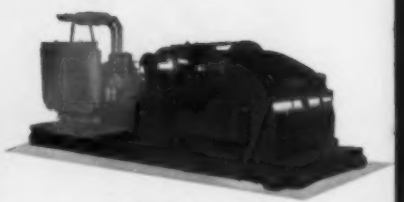
NATIONAL T-8 AND T-8-S RIGS
RATED AT 80 H.P.



NATIONAL T-12 AND T-12-S RIGS
RATED AT 120 H.P.



NATIONAL T-20 AND T-20-S RIGS
RATED AT 200 H.P.



NATIONAL T-32 RIGS
RATED AT 320 H.P.

DOWNTIME . . . FASTER OPERATIONS"

Here's why National Truck- and Trailer-mounted Rigs will help you set new operating records . . .

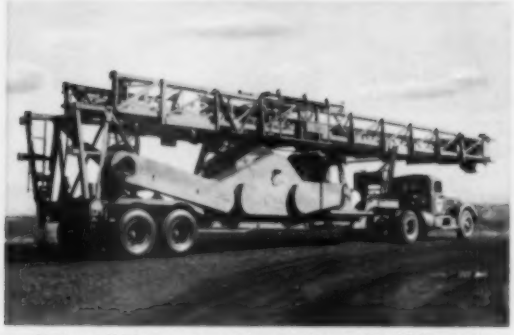
Rugged construction—These National truck- and trailer-mounted rigs are really built to take the punishment of year-around "mobile operations" in every kind of terrain. They have the same experienced design features, quality construction and service life that you expect to find in big National rigs.

On and off the job fast!—More and more operators are telling us how exceptionally fast these National rigs are on rig-ups and tear-downs. Compact, sectionalized design, adapted for your truck or trailer requirements, means that you move drawworks, pumps, engines and mast quickly—keep down-time between jobs at a minimum. These rigs can also be supplied as skid mounted units, if you prefer.

Built-in performance—Extra service life features are part of every National truck-and-trailer mounted rig. You'll find roller bearing mounted free-running drums, air controls, air-actuated clutches and fully enclosed cascade lubrication for all chains and sprockets. And because these rigs utilize torque converter drive, you can be sure of shock-proof operation and an infinite number of running speeds.

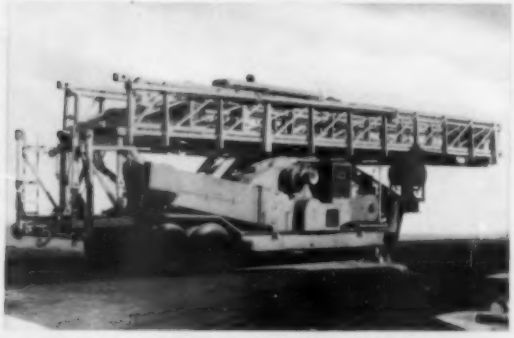
Get all the facts now—The National Supply representative or store in your area can give you complete descriptive bulletins on each of National's portable rigs. They can also supply operating information on such rigs in your own area. Why not let them be of service to you soon?

MOUNTED TO SUIT YOUR REQUIREMENTS



National T-20 in road position, equipped with 95 ft. mast

Trailer-mounted T-12 & substructure



Rotary drive side, National T-32 Rig with 96 ft. mast

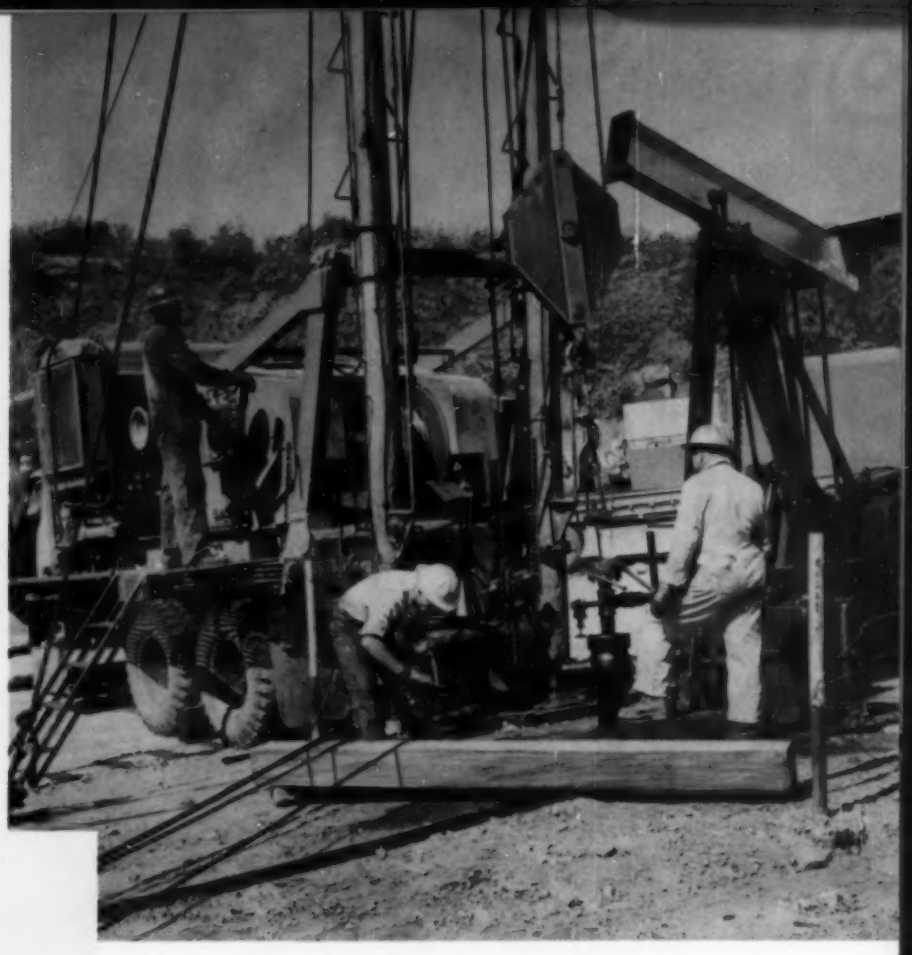
THE NATIONAL SUPPLY COMPANY

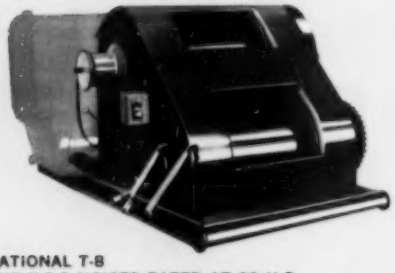
MAIN OFFICE: Two Gateway Center, Pittsburgh 22, Penna.
DIVISION OFFICES: Denver; Ft. Worth; Houston; Toledo; Tulsa; Torrance
CANADA: The National Supply Company, Ltd., 200 F. W. Clark Building, 709 Eighth Avenue, West, Calgary, Alberta
EXPORT: 600 Fifth Avenue, New York 20, N.Y., U.S.A.; City Wall House, Chiswell Street, London E. C. 1

NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

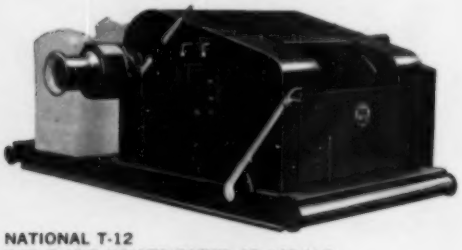
For information on National Hoists, see the next page

For new speed on your well-servicing jobs





NATIONAL T-8
AND T-8-S HOISTS RATED AT 80 H.P.
NORMAL SERVICING RANGE: 2000-4000 FT.



NATIONAL T-12
AND T-12-S HOISTS RATED AT 120 H.P.
NORMAL SERVICING RANGE: 3000-6000 FT.

NATIONAL HOISTS

Tailor-made for the versatile performance needed in well-pulling and well-servicing operations, National hoists are exceptionally compact and lightweight . . . especially suited for truck and trailer mounting.

Constructed as single units, drawworks and engine are mounted on a heavy steel H-beam skid frame. For maximum convenience in transportation or truck mounting, overall dimensions of National hoists conform to all highway width limits.

Operating features in these National hoists parallel the quality features found in all National rigs. Besides free-running drums, optional sand reels, air-operated controls and clutches, these National hoists utilize torque converter drive for smooth operation, a great variety of running speeds.

Get complete details on these highly versatile National hoists from the National Supply Representative or store in your area soon.

THE
NATIONAL
SUPPLY
COMPANY

MAIN OFFICE: Two Gateway Center, Pittsburgh 22, Penna.
DIVISION OFFICES: Denver; Ft. Worth; Houston; Toledo; Tulsa; Torrance
CANADA: The National Supply Company, Ltd., 200 F. W. Clark Building, 709 Eighth Avenue, West, Calgary, Alberta
EXPORT: 600 Fifth Avenue, New York 20, N.Y., U.S.A.; City Wall House, Chiswell Street, London E. C. 1

NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

FIG. 1. **Dual zone completion with parallel tubing strings** inside 5½-inch casing has two sucker rod pumping units. One string of tubing is 2-in.; the other, 1½-in.

P 148.

SPECIAL *Well Workover* FEATURE

Parallel Strings and Pumps Run In 5½-in. Casing

Here's a workover job that saved the cost of a new well. It has parallel tubing strings and independent sucker rod pumping units.

Thomas C. Aitken
Sun Oil Co., Gainesville, Texas

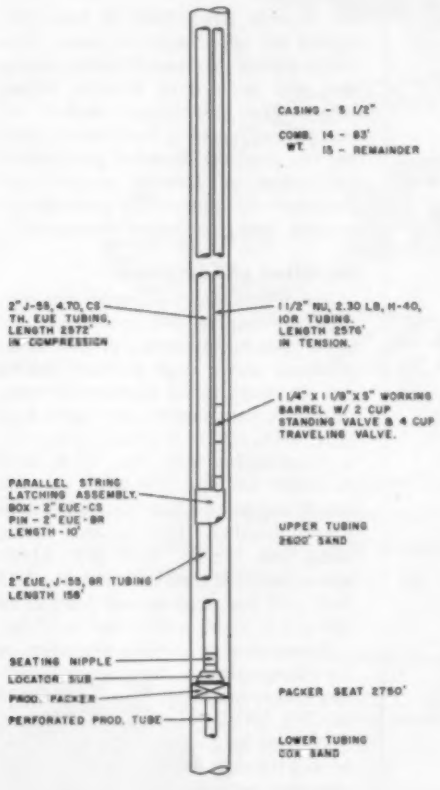

CASING - 5 1/2"
COMB. 14 - 83'
WT. 15 - REMAINDER
2" J-55, 4.70, CS TH. EUE TUBING, LENGTH 2572' IN COMPRESSION
1 1/2" NU, 2.30 LB, H-40, IOR TUBING. LENGTH 2576' IN TENSION.
1 1/4" X 1 1/8" X 5" WORKING BARREL W/ 2 CUP STANDING VALVE & 4 CUP TRAVELING VALVE.
PARALLEL STRING LATCHING ASSEMBLY. BOX - 2" EUE - CS PIN - 2" EUE - 8R LENGTH - 10'
UPPER TUBING 2600' SAND
2" EUE, J-55, 8R TUBING LENGTH 158'
SEATING NIPPLE
LOCATOR SUB
PROD. PACKER
PERFORATED PROD. TUBE
PACKER SEAT 2750'
LOWER TUBING COX SAND

FIG. 2. **Down-hole equipment** used in the dual, parallel string completion.

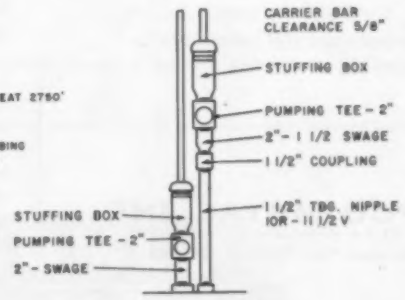

CARRIER BAR CLEARANCE 5/8"
STUFFING BOX
PUMPING TEE - 2"
2" - 1 1/2 SWAGE
1 1/2" COUPLING
1 1/2" TBG. NIPPLE IOR - 1 1/2 V
STUFFING BOX
PUMPING TEE - 2"
2" - SWAGE

FIG. 3. **Well-head installation** spaced to give carrier bar clearance of ⅝-in.

A well that had originally been dually completed through the annulus and a single string of tubing was re-completed using parallel strings of two-inch and 1½-in. tubing inside 5½-in. casing. It was equipped with independent sucker rod pumping units.

The cost of the installation totalled approximately $9000 including the tubing, an additional pumping unit, rods, special couplings, pumps, well head, stuffing boxes and miscellaneous. This cost represents a savings of about $20,000 above the cost of drilling an additional well.

The particular well selected for this dual installation was in the Walnut Bend field, Cooke County, Texas. It had originally been completed as a dual in April, 1948. Total depth was 2917 ft and 5½-in. casing was set at 2908 ft. It was completed in the Walnut Bend 2900-ft Cox Sand and in the Walnut Bend 2600-ft Sand.

A retrievable hookwall packer was

run for zone separation and single rod string dual pumping equipment installed to lift the wells.

Maintenance costs proved excessive and the method was abandoned after some time. A retainer type packer was run and set at 2750 ft for zone separation. The well was returned to production as a single completion in the lower zone and produced in this manner for some years. But recent development of the Walnut Bend 2600 ft sand presented the opportunity to more effectively deplete this zone by recompleting this well as a dual. Parallel tubing strings and independent sucker rod pumping appeared to be the most efficient and practical means of production. Utilization of existing surface and downhole equipment also provided attractive savings on initial investment.

The Author

Thomas C. Aitken is petroleum engineer with the Sun Oil Company at Gainesville, Texas. He has been with the company since he graduated from Texas A&M in 1951 with a B.S. degree in petroleum engineering. He started with Sun on the Gulf Coast, picked up three years experience in offshore drilling and production prior to being transferred to North Texas in 1955.

Selection of Equipment

The selection of equipment was governed by existing well conditions. The lower zone had become a prolific water producer and a large diameter tubing was necessary to lift required volumes of fluid. Consequently, a string of 2-in. EUE, J-55, 4.70 lb-ft CS tubing was run in combination with 2-in. EUE, 4.70 lb-ft J-55 8R pipe. The latter was run below the point where the two strings would parallel. The second tubing string was 1½-in., 2.30 lb-ft, H-40, non-upset, 10R pipe with 1½-in., 2.75 lb-ft, J-55 couplings turned down to an OD of 2 3/32-in. and beveled to 37 deg.

Summation of outside diameters of the tubing strings at the upset and coupling was found to be: 2-in. EUE 2.688 in., 1½ NU-2.094-in.; total 4.782 in. The ID of the 5½-in. casing was 4.950 in. and the drift diameter 4.825 in. The clearance between tubing strings, at the upset and couplings, was a maximum of 0.168 in. and a minimum of 0.043 in.

The retainer type production packer set at 2750 ft governed the lower tub-

Four Times Longer Life*

from Ampco Polished Rod Liners

...with fewer shut-downs for repairs, less loss of production, lower maintenance costs.

You can retard mechanical wear, corrosion and erosion with Ampco polished rod liners. Even in many of the toughest oil-well services, you can get four times longer life with these remarkable wear-resistant liners—made from Ampco Metal.

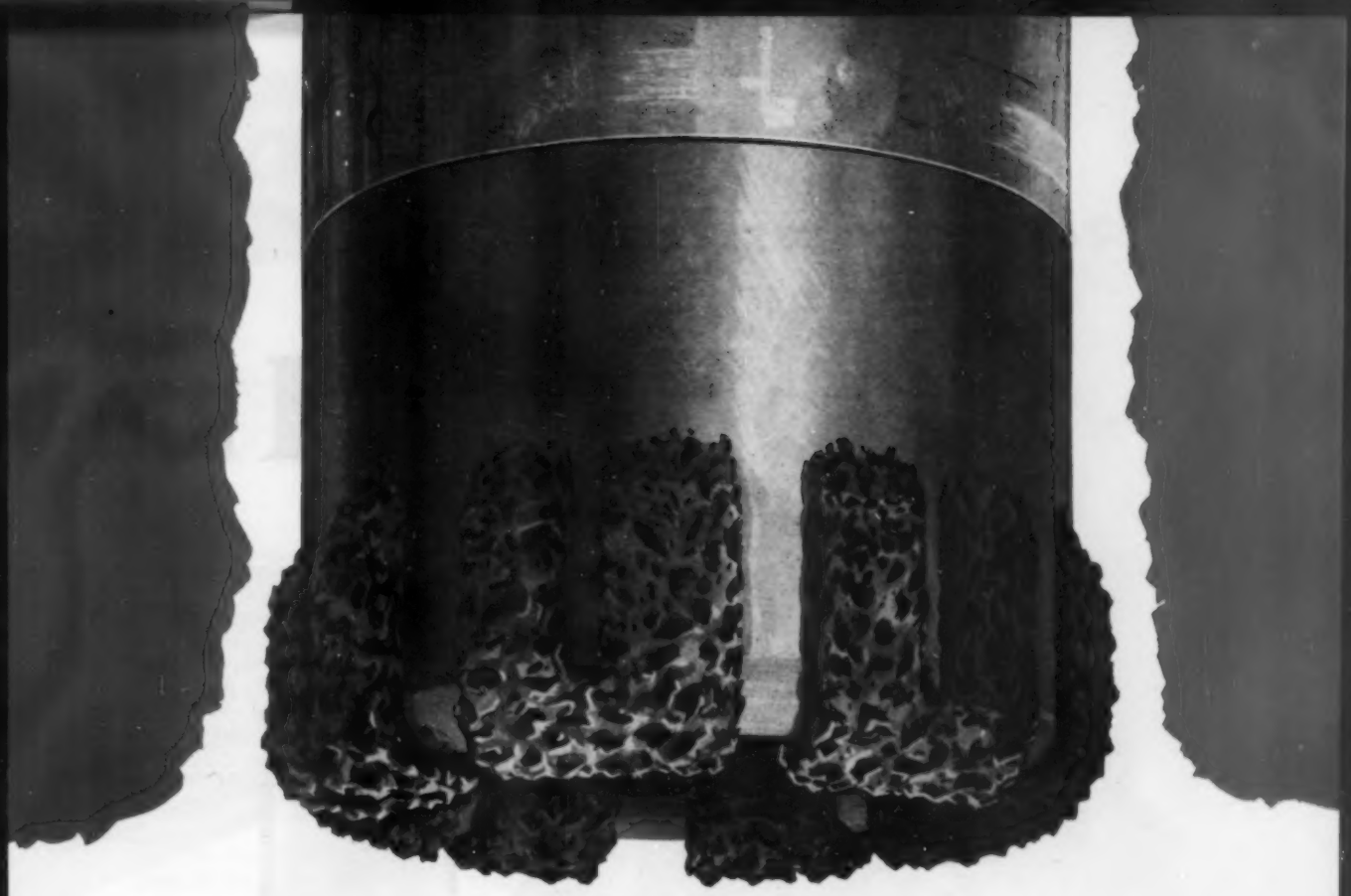
Find out today how much money you are spending for sliding wear and corrosion. Check on the "hidden costs" of ordinary liners. Then see how many dollars you can save with Ampco polished rod liners. For more information, just write us.

*Name of this user upon request.

AMPCO METAL, INC.
Dept. PE-9 • MILWAUKEE 46, WISCONSIN
West Coast Plant • Burbank, California

AMPCO ® The Metal Without an Equal

PR-22



KLUSTRITE'S UNIQUE DESIGN COMPETES WITH DIAMONDS

HOMCO
HOUSTON OIL FIELD MATERIAL COMPANY Inc.

A HOMCO "Klustrite" Rotary Shoe takes over when the cutting gets rough. Exceptional field runs are being reported daily.* There is a "Klustrite" shoe designed for each particular wash-over operation, whether it be caused by junk or hard formation. Write for your copy of the Homco "Klustrite" brochure.

COMPLETE 24-HOUR SERVICE ANYWHERE, ANYTIME. LET ONE CALL DO IT ALL.

*Homco requires that all supervisors make a report on all runs of the "Klustrite" shoe.

• DIRECTIONAL DRILLING • OILFIELD SUPPLIES • FISHING AND CUTTING •
THE OIL INDUSTRY'S MOST *Complete* SERVICE

HOMCO
HOUSTON OIL FIELD MATERIAL COMPANY Inc.
HOUSTON, TEXAS

New York Office
50 Madison Avenue
New York, N. Y.

THE WORLD'S LARGEST INDEPENDENT OILFIELD SUPPLY AND SERVICE ORGANIZATION

Reed Announces

In

Research and engineering development maintain

Write or wire for complete information... or have your nearby Reed man explain the economic advantages of Inarclad hard faced tool joints.

arclad®

Pronounced "Inner Clad"

Reed's advanced hard metal application for Tool Joints...

Inarclad utilizes Reedite hard metal to protect tool joints as do Reed's two other methods (Surface Concentration and Deep Penetration) . . . but . . . Inarclad differs in the process used in that Inarclad welds the hard metal into the tool joint steel rather than binding the hard metal onto the surface of the tool joint.

The application of the hard metal with the new method is done by an automatic electric welding machine utilizing an inert arc process. Using a non-consumable electrode, an electric arc melts the tool joint steel into a puddle at the proper spot. Hard metal grains are fed into the puddle automatically. The arc is shielded by a continuous flow of inert gas to prevent contamination or oxidation of the steel during the melting process.

Unretouched photo of Inarclad cross section sample.

ADVANTAGES

1. **Inarclad uses the high alloy steel of the tool joint itself as the binder for the hard metal. Reduces chances of spalling or flaking!**
2. **The steel of the tool joint will not become oxidized by the heat of the weld because the arc is operating in an inert atmosphere.**
3. **The weld is made by an automatic machine which eliminates human errors. Superior weld quality!**
4. **Reedite is fed into the weld by machine, thus giving a better distribution of hard metal throughout the band. Uniform, measured amount of hard metal is put into each band!**
5. **The hard metal is distributed uniformly in depth through the band. This assures that a uniform number of hard metal grains are always resisting abrasive wear until the hard metal is worn completely away. Uniform wear rates!**
6. **The hard metal bands have a concentration of hard metal approaching that of Surface Concentration method and equal the depth of Deep Penetration method. More hard metal!**
7. **The hard metal is applied to the tool joint without recessing and results in a slight surface build up. This build up equals approximately 1/32 in., which increases the tool joint O.D. about 1/16 in. The O.D. of the tool joint remaining after all the hard metal has worn away is 1/16 in. larger than it would be if the same bands had been laid in recesses.**

REED **leadership in tool joint design.**

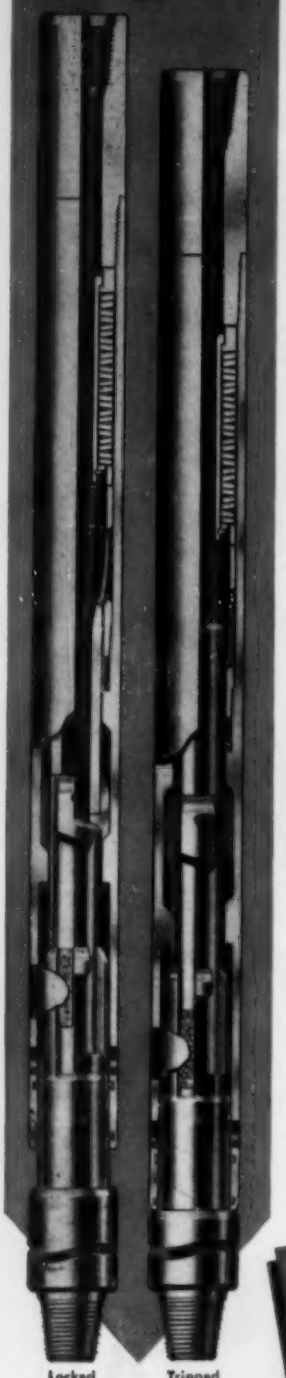
THE MARK OF QUALITY

REED ROLLER BIT COMPANY, HOUSTON 1, TEXAS NEW YORK LONDON BUENOS AIRES

For running in the drill string . . .

Positive JAR-DOWN ACTION

. . . plus Safety Joint protection!



Locked Position

Tripped Position

See the Shaffer section of your Composite Catalog.

THE SHAFFER-WAGGENER BUMPER SAFETY JOINT

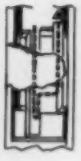
There is no other tool like the Shaffer-Waggener Bumper Safety Joint. It combines—in ONE tool—a choice of *jar-down* and *releasing* actions, both under complete control of the operator. What's more, the tool is so rugged it is run as part of the drill string to protect against stuck pipe.

In actual well service it has operated easily at depths below 18,000 feet, and has given no operating problems even in directionally-drilled wells with extreme slant.

Jar-Down Action

▶ **RUN IT IN THE DRILL STRING**—It is specifically designed to withstand the continuous vibration and heavy torque loads of today's drilling operations.

▶ **TO JAR DOWN** whenever the drill pipe threatens to stick—or to drive drill collars out of keyseats and to free "balled-up" bits—simply slack off weight equivalent to about 2,000 feet of drill pipe onto the tool. This releases the tripping mechanism, automatically striking a sharp down blow. Raising the string automatically re-sets the tool for another blow—and blows can be struck repeatedly as fast as the string can be raised and lowered. And no torque or twisting strains are placed in string!



Releasing Action

▶ **TO RELEASE,** in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. Only one-sixth turn of the tool rotates the drive keys into unlocking slots so that complete release is effected by continuing to raise the string.

ANOTHER ADVANTAGE—the tool transmits full torque loads in *either* direction through three rugged drive keys—not through easily-damaged threads. It is the strongest joint in the string—not the weakest, as with conventional safety joints.

Also, the tool can be re-connected again by simply lowering the top portion over the lower portion and reversing the releasing action. It is ideal for use in fishing strings!

Free 8 page bulletin gives the full story on the Shaffer-Waggener Bumper Safety Joint. Write for it—or ask your nearest Shaffer representative.

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

33 YEARS

FIG. 4. **Actual well-head installation.** Lower zone pump has 44-in. stroke; upper zone pump has 37-in. stroke.

ing string as far as anchoring the tubing for pumping. A conventional production tube and locator sub were run and the lower string set in compression. A parallel string latching anchor was run in the lower tubing string and the small diameter tubing was latched into this tool and hung in tension.

An insert type pump was run in the lower tubing on ¾-in. rods. A working barrel type pump, of maximum OD. was selected for the upper tubing and the four cup traveling valve was run on ⅝-in. rods with special couplings turned from 1½-in. to 1⅜-in. and case hardened. The working barrel was used in the upper string due to the operators ability to pull this string independently of the lower tubing. (See Fig. 2.)

The wellhead was an application of existing parallel string equipment but was altered slightly for this installation. The head provides independent suspension and packing for the two tubing strings. Nippling-up and landing tubing through the wellhead is simple and the initial cost is nominal. (Note Fig. 3.)

Flush type polish rod carrier bars were used in this installation. The upper tubing was equipped with a 1⅛-in. common steel polished rod and a Type "A" carrier bar. The lower tubing string

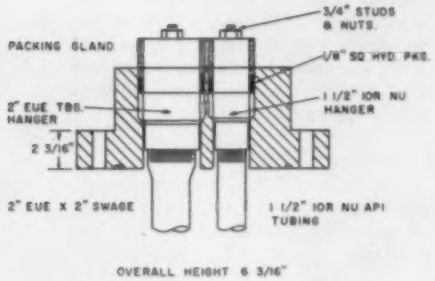

3/4" STUDS & NUTS
PACKING GLAND
1/8" SQ HYD. PKG.
2" EUE TBG. HANGER
1 1/2" IOR NU HANGER
2 3/16"
2" EUE X 2" SWAGE
1 1/2" IOR NU API TUBING
OVERALL HEIGHT 6 3/16"

FIG. 5. **Dual string head.**

was hung on a Type "B" carrier bar with a 1¼-in. polished rod. The latter type is hinged, and can be easily hung. It gives maximum clearance. (The actual clearance between carrier bars after completion was ⅝-in. See Fig. 4.)

Pumping equipment consisted of the existing 44-in. stroke, 114,000 in.-lb unit on location and a 37-in. stroke, 57,000 in.-lb unit moved in to lift the upper zone. A carrier bar guard, consisting of a sheet of plate steel and anchored to the units, was installed prior to starting operation.

Completion

The actual completion operation consisted of pulling rods and tubing running the combination 2-in. EUE 8R and 2-in. EUE CS tubing with the parallel string latching anchor above the upper perforations, and hanging this string in compression. The 1½-in. nonupset tubing was then run, latched into the anchor, spaced out, and landed in tension. Pump and rods were run in the lower tubing string and backed off below the wellhead. The lower tubing rods were fished and spaced, and the polished rod and stuffing box installed and landed. Dual-Pac Type boxes were used for both strings. The upper tubing rods were then spaced, polished rod installed and sufficient clearance allowed to re-pack lower stuffing box. The carrier bar guard was bolted to the units and wellhead. The pumping units were then placed in operation.

Cost

The cost of installation totalled approximately $9000, including all equipment. This cost represents a saving of about $20,000 above drilling an additional well to produce the upper sand. During a development of this type, these savings will pyramid, representing considerable capital investment on a field wide scale. In turn, increased production from additional wells adds income and will more economically and effectively deplete these leases. This process, of course, increases costs slightly on a new well, but considered

For fishing, testing and core-drilling strings . . .

. . . plus Safety Joint protection!

THE SHAFFER OIL-SEALED JAR SAFETY JOINT

The Shaffer Oil-Sealed Jar Safety Joint is the only tool that combines a choice of *jar-up* and *releasing* actions, both under complete control of the operator at all times. What's more, all operating parts are sealed in a chamber filled with clean oil, fully protected against mud, sand and corrosive fluids.

The sealed-in-oil protection not only safeguards against abrasion and corrosion, and minimizes pressure differentials on packing elements, but also insures constant operating characteristics at all depths. This makes the tool ideal for fishing, testing and similar strings where light connections and equipment are used!

Jar-Up Action

▶ **JARRING ACTION IS AUTOMATIC**—simply raise the drill string until tension equals the pre-set tripping load, whereupon a sharp up blow is struck. Lowering the tool automatically re-sets the tripping mechanism for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.

Releasing Action

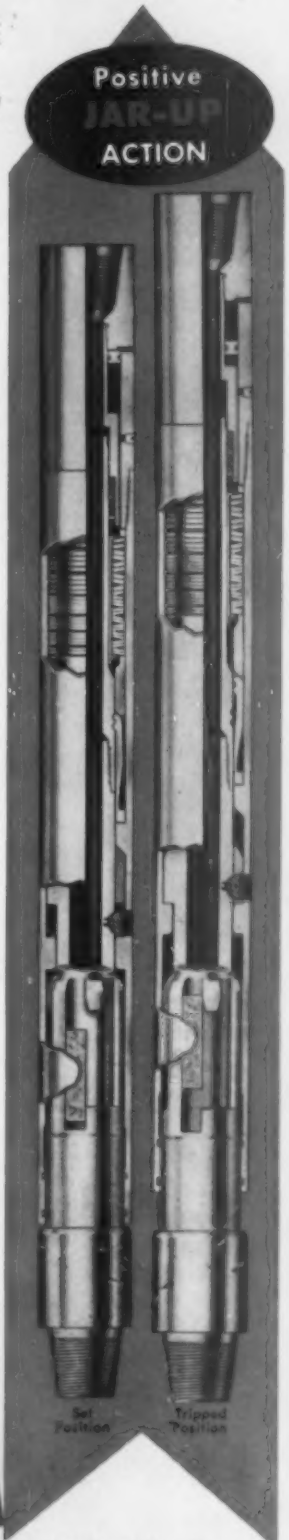
▶ **ONLY STRAIGHT PULL** is necessary to operate the tool—no torque or other secondary operations to affect the light connections commonly used in fishing, testing and coring strings.

▶ **TO RELEASE,** in the event the fish or stuck string cannot be loosened, simply trip the tool and apply reverse torque as the string is slowly lowered. Only one-sixth turn of the drive keys rotates them into an unlocking slot whereupon raising the string allows the parts to unlock.

AND NOTE THIS—not only does the tool transmit full torque loads in *either* direction, but no threads are used in the releasing mechanism. Therefore there's no risk of torque over-tightening the tool—nor can reverse rotation accidentally release it.

Also, force of the blow is absorbed by integral knocker heads—not by easily damaged drive keys or threads. The tool is designed for *sustained* jarring operations. And since it does not depend upon friction for its tripping action, the Jar Safety Joint always operates with the same pre-set action. Light strings are not subjected to unpredictable loads!

Free 8 page booklet gives many other facts about the Shaffer Oil-Sealed Jar Safety Joint. Write for it—or ask your nearest Shaffer representative.



See the Shaffer section of your Composite Catalog.

Levingston

builds the industry's finest

SUBMERSIBLE DRILLING BARGES

Drilling barge "W. M. Keck, Sr." on a deep well location in South Louisiana.

Levingston

SHIPBUILDING COMPANY • ORANGE, TEXAS

The Oil Industry's Shipyard

DRILLING BARGES • WORKOVER BARGES • OFFSHORE TENDERS • CREW BOATS • TUGS

on the basis of twin wells the savings realized from the dual well again become effective. The application of this technique can be applied to deeper wells, governed by the tubing strings used, and again savings of notable magnitude can be realized.

Conclusions

The use of dual completion technique in small diameter casing strings offers many attractive advantages. The following are outstanding examples:

1. **The use of existing well bores in developed field for adidtional and more efficient production.**
2. **Material savings on casing strings either in additional development or planned dual installations.**
3. **Meeting off-set obligations without drilling additional wells.**
4. **Dual pumping installations in areas of low productivity.**
5. **Independent tubing string for upper zone and separate rod strings and pumps for both strings.**

The installation of equipment was accomplished in a minimum time with no operational difficulties encountered. Ability to run and pull tubing was evaluated and was accomplished with ease. Continued use of this process in the Walnut Bend Field promises full development with a minimum number of holes and maximum production from existing wells.

Acknowledgments:

The author wishes to express his appreciation to the Sun Oil Company Operating Department for granting permission to publish this paper and to James C. Roe, Lufkin Foundry for his assistance and photographs. * * *

To: THE PETROLEUM ENGINEER

P. O. Box 1589, Dallas

CHANGE MY ADDRESS, beginning

with the _____ issue,

FROM: _____

_____

_____

TO: _____

_____

_____

A Rod pump with an AUTOMATIC SHIFT?

Yes sir, that's just what we said. And scaled down in size to produce the smallest stripper well too. That's why we call it the STRIPPERMATIC.

Until recently, we thought our 1-1/16" Bore Petrol "A" pump was about as small as any commercial oil well needed, but operators showed us any number of profitable stripper wells that would pound fluid in thirty minutes with a 1-1/16" pump.

So the STRIPPERMATIC was born. It's a compounded two stage pump. When the fluid is there, it pumps with a 1-1/16" displacement. When the level drops, the full 1-1/16" bore merely serves as a charging pump for the second stage annular chamber, and this is equivalent to a mere 5/8" bore pump. When this automatic shift takes place, there is a drop in load range on the sucker rods, the torque drops on the unit, and the power consumption goes down. Gas lock is eliminated by the two stage construction so both production and pump life are improved.

All this pump for less than two hundred dollars? Yes sir, even the initial cost will appeal to a stripper operator. If you have a small well that can use a versatile pump like this, or need its big brother, the Ratio-Compound for pumping foamy or gassy oil, or for pumping under a packer, contact your nearest OILMASTER representative... there's one close by.

STRIPPERMATIC

... the new 2 stage pump for the smallest stripper wells

oilmaster PUMPS
FOREMOST IN THE INDUSTRY

FLUID PACKED PUMP COMPANY
Main Office and Plant, Los Nietos, Calif.
Distributed by the National Supply Co., Pittsburgh, Pa. Export: The National Supply Co., Export Division, 600 Fifth Ave., New York • Co-Distributors: Union Supply Company, Beacon Supply Co., Industrial Supply Co.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Why Mission Pistons and Mission Liners Last Longer When Used Together

Nothing but the finest will bear the name of MISSION MANUFACTURING CO

Both of the dimensions being checked below are vital because *both* affect the clearance between piston flange and liner bore. Too much clearance means short life for piston rubbers and liners.

Mission Pistons and Mission Liners last longer when used together because they fit closely and wear slowly. We have taken extra care with both to postpone the day when clearance becomes excessive. Here are some of the things we do:

We machine piston flanges to extra close tolerances to keep initial clearance low. Then we provide a wear groove so you can tell when to change the piston body.

We induction harden the flange to reduce the rate of piston wear. Finally, we apply a special treatment to the flange to prevent galling.

We machine Mission Liners to extremely close tolerances. Then we give the fine alloy steel a precision induction hardening treatment that results in a hard, uniform, wear-resistant bore.

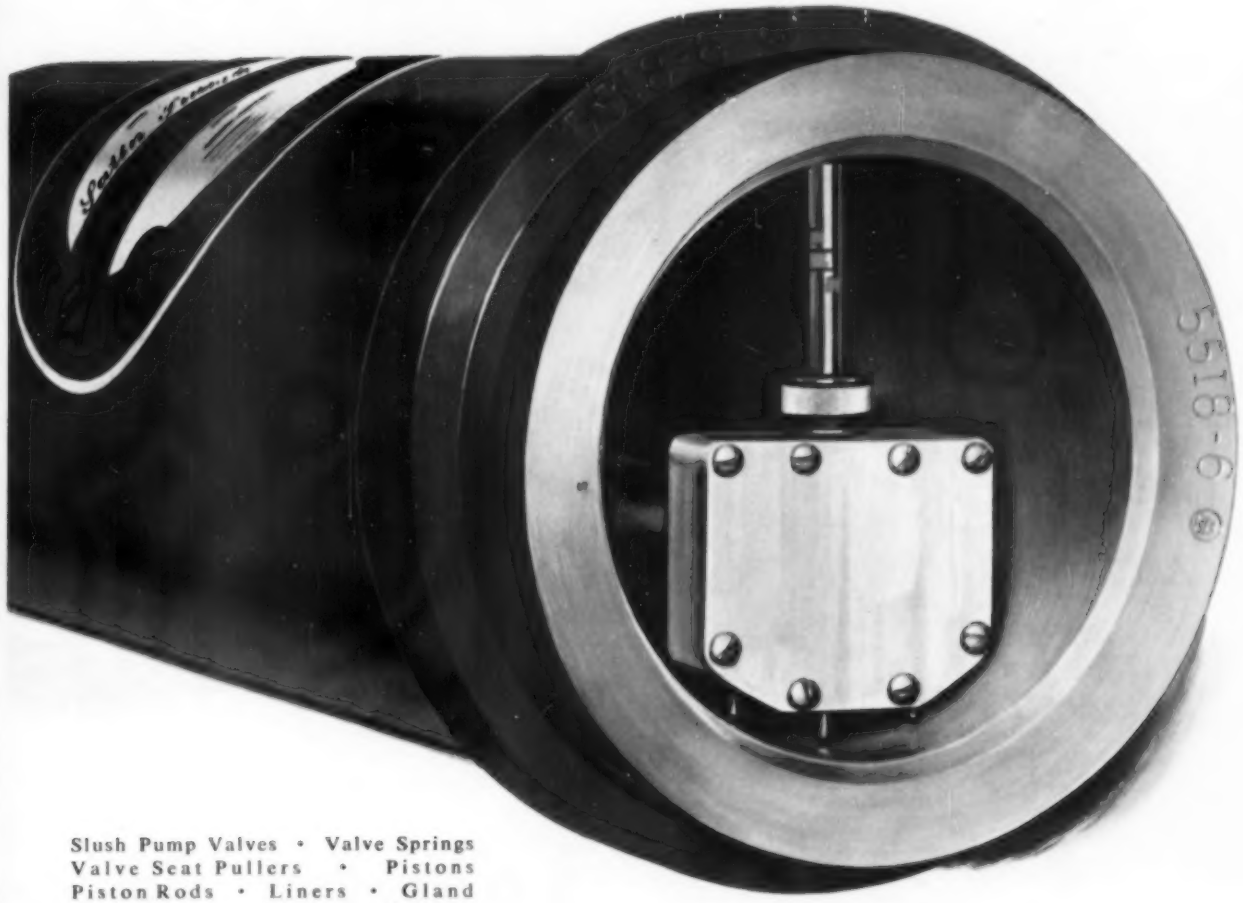
Finally, we "Satin Finish" the bore to further increase liner life.

To get *all* the life built into Mission Pistons and Mission Liners, however, they must be used together.

Mission Pistons, for example, will give outstanding service in any make of liner — but an oversize or excessively worn liner will shorten piston rubber life.

Both Mission Pistons and Mission Liners are guaranteed to give satisfactory service or your money will be refunded. Order them both from your supply store. You can't match the service you get when you use them *together*.

MISSION MANUFACTURING CO. • P. O. Box 4209 • Houston, Texas • Cable Address—"Missco" • Export Office: 30 Rockefeller Plaza, New York
In The United Kingdom: MISSION MANUFACTURING CO., LTD. • 17 Hanover Square • London, W. I. England • Cable Address—"Missoman"

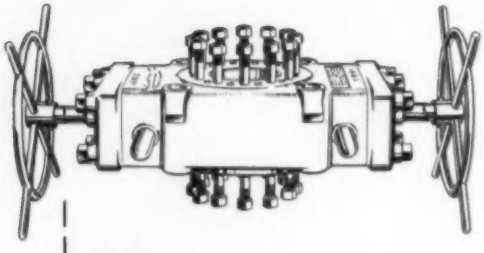


Slush Pump Valves • Valve Springs
Valve Seat Pullers • Pistons
Piston Rods • Liners • Gland
Packings • Slips • Swabs
Centrifugal Pumps • Plug Valves

Perfect for Work-over Rigs . . .

Guiberson BLOWOUT PREVENTER

with Chain Drive



TYPE A
BLOWOUT PREVENTER
MANUAL DRIVE

- This work-over special is also ideal for small hole drilling.
- Chain drive provides tight seal with one man operation.
- Two types — A for working pressures to 3000 psi (6000 psi test) — 7⅜″ opening. Manual or chain drive.

  B for working pressures to 2000 psi (4000 psi test)—9-1/16″ opening. Chain drive only.
- Short and compact design — body is only 11½″ high.
- Keeps well head equipment close to ground.
- Designed to use two preventers in combination without need of flanged adapters.
- Connecting tie bolts and nuts furnished at no extra cost on original sale of dual preventers.
- Universal slide designed to handle blank rubbers or 2″, 2½″, 3″, 3½″, 4″ tubing sizes or 5½″, 7″ casing sizes.

THE
GUIBERSON
CORPORATION
ESTABLISHED 1919 • DALLAS, TEXAS, U. S. A.
Sold By Leading Oil Field Supply Stores Everywhere

P 951.132

Evaluation of Workover Before and After

SPECIAL Well Workover FEATURE

J. J. Arps *Vice President, Economics and Evaluation*
The British-American Oil Producing Company, Dallas, Texas

THE need for a workover job is usually apparent from a study of the production performance of a well. This discussion will not concern itself with cases in which something is obviously wrong with the mechanical condition of the well or well bore, such as casing leaks or collapse, excessive sand production, excessive water or gas production, or bad cement jobs, all of which fall in a separate category.

Emphasis is placed here, instead, on unusually low productive capacity, which may be due to a variety of different causes. A gradual or sudden reduction in fluid output from a well is usually the first indication that a workover should be considered.

Production history essential. Keeping accurate production curves on wells or leases is, therefore, of vital importance. Such curves should include all pertinent operational details to enable the engineer to review the entire picture at a glance. As an example, there is included herewith as Fig. 1 a typical well production curve as kept by The British-American Oil Producing Company. Ten-year, three-cycle, semi-logarithmic paper is preferably used with the horizontal linear scale divided in months.

Both the average oil production (heavy curve) and total fluid production rates (light curve) are shown in barrels per day for each month. The gas-oil ratio curve is shown separately as a dashed line. Actual gas-oil ratio measurements are shown as small circles. Additional data pertaining to type of lift, pump stroke and speed, choke size, etc., are added as needed.

Production during each year and cumulative at the end of the year are marked along the bottom. Pertinent data on well depth, etc., are shown in the upper right-hand corner. Such curves are kept by British-American on all company wells. The vertical scales and the manner in which the curves are maintained are standard throughout the company. In ad-

FIGURE 1

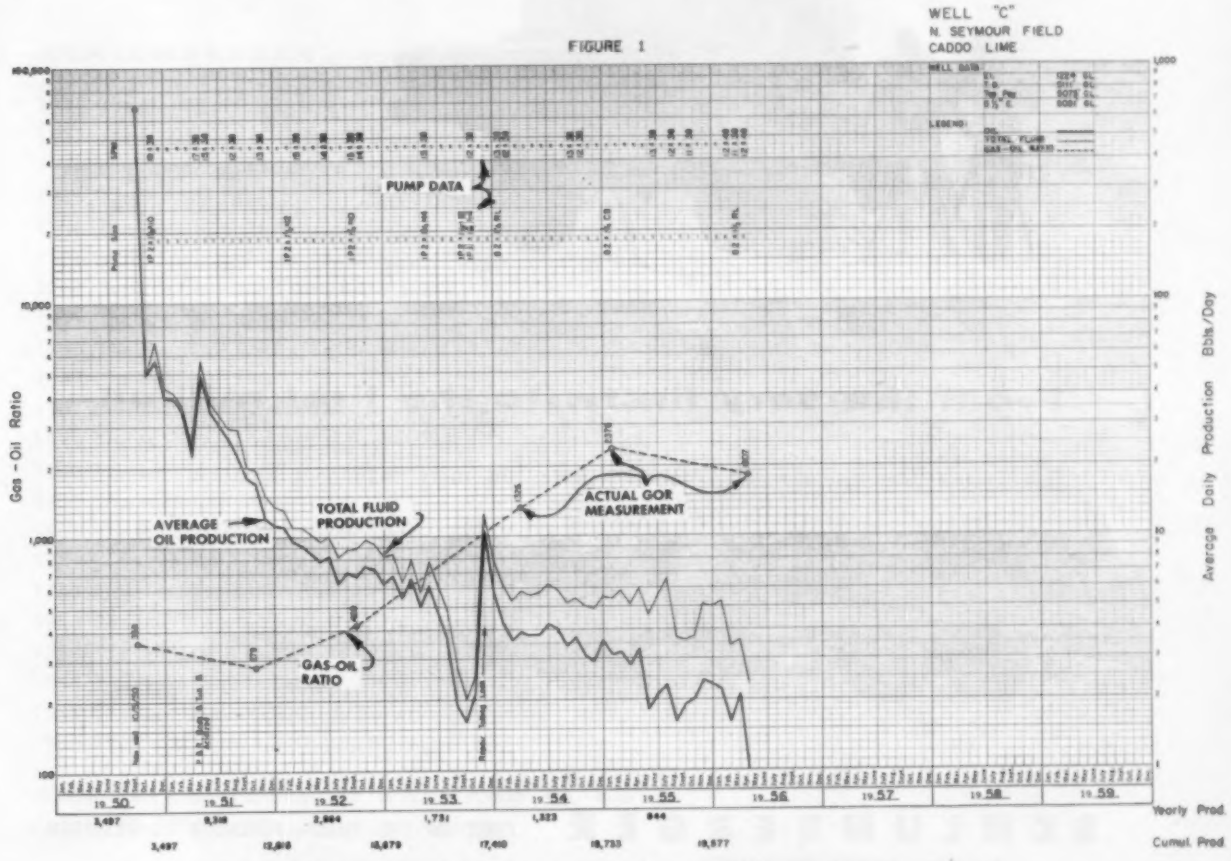
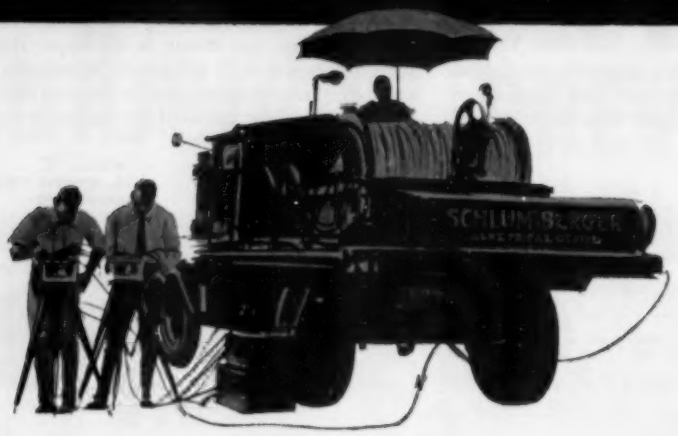


FIG. 1. **Typical well production curve** maintained by British-American. Ten-year, three-cycle semi-log paper is preferable, with the horizontal linear scale divided in months.



From the very first...to the first million

The fact that oil companies have run more than a million Schlumberger operations can be attributed to...continuous research... engineering...extensive field experience...all have combined to provide the industry with the very best in new and improved services year after year.

SCHLUMBERGER
WELL SURVEYING CORPORATION

FIRST IN THE FIELD—FOREMOST IN RESEARCH

SCHLUMBERGER — *first in the field with these services* —

1927 The Electrical Resistivity Log
1931 The S. P. Log
1935 The Temperature Survey
1936 The Sample Taker
1936 The Automatic Film Recorder
1936 Multi-Spacing Resistivity Curves for Deep Investigation
1940 Surface Controlled Directional Survey
1941 The S. P. Dipmeter
1946 The Magnetic Casing Collar Locator
1947 The Induction Log
1947 The Resistivity Dipmeter
1949 The MicroLog
1950 The Laterolog
1951 The Microlaterolog
1951 The Expendable Perforator
1952 The Continuous Resistivity Dipmeter
1953 The Hard Formation Sample Taker
1954 The MicroLog-Caliper
1955 The Formation Tester
1955 The Fluid Sample Taker
1955 The Long Interval Velocity Survey
1956 The Combination Induction Electrical Log

Schlumberger will continue to be...
First in the field — Foremost in research

FIGURE 2

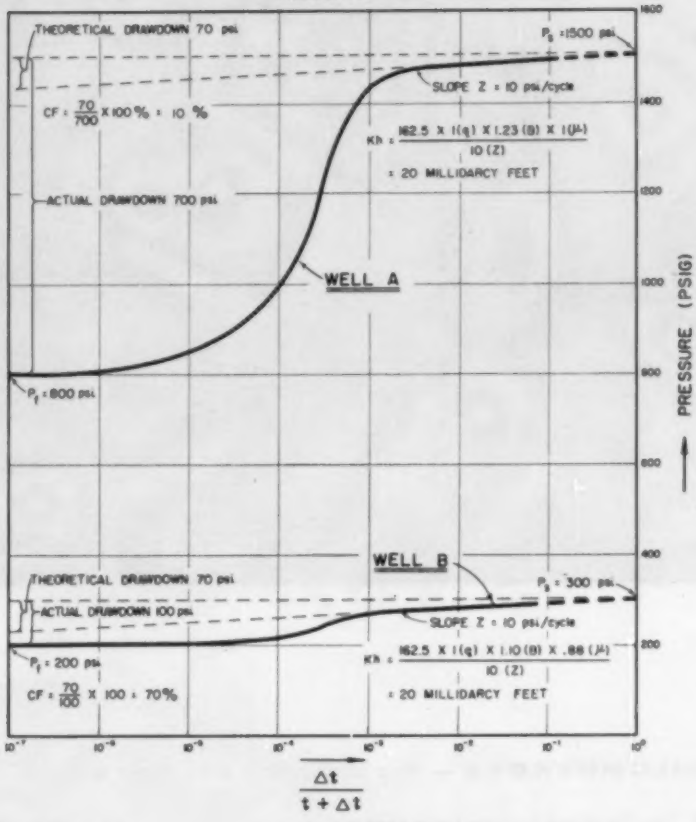


FIG. 2. Pressure build-up curves for Wells "A" and "B." Analysis of these curves illustrates that Well "A" is a likely candidate for a successful workover, while little improvement could be expected from Well "B."

dition, rate-cummulative curves are kept on a lease basis and plotted on regular coordinate paper. Examples of this type of curve are shown in Figs. 4 and 6.

Analyzing production curves. Since both total fluid and oil production curves are graphically recorded, it is easy to determine whether: (a) decreasing oil production is due to decreased oil percentage with total fluid remaining constant. This could mean progressive watering-out without anything being wrong with either the pump capacity or the well productivity, or (b) decreasing oil production with both oil and total fluid production falling off. This could mean that something may be wrong with the pumping equipment. If verification of this possibility shows that the pump is operating satisfactorily, productivity of the well should be investigated.

The Author

J. J. Arps is vice president in charge of the Economics and Evaluation Department of The British-American Oil Producing Company, Dallas, Texas. A native of The Netherlands, he was graduated in 1932 from the Technical University at Delft, Netherlands, with a master's degree cum laude in mining engineering. He worked in Eastern Europe, the Far East, South America and the U.S. for Shell before joining British-American in 1940 as district engineer for the Gulf Coast area. From this assignment, he moved steadily upward through chief engineer, assistant general superintendent, acting production manager, manager of research and economics, to his present post. He is active in several professional societies, currently serving as chairman of the Dallas Section of AIME. His contributions to the technical literature have included publications in the field of decline curve analysis, interpretation of bottom-hole surveys, and estimating reserves.

Bottom-Hole Pressure Data

Decreased well productivity can be due to either (a) loss in bottom-hole pressure or (b) loss in productive index.

If low bottom-hole pressure is the cause of decreased well productivity, there is not too much that can be done to remedy the situation, but cases of decreased productive index oftentimes may be successfully remedied by various stimulation methods.

To distinguish between the two and thereby avoid unnecessary workovers, a bottom-hole pressure buildup curve, properly interpreted, is in many cases a necessity. In the case of a flowing well, the bomb is run to bottom while the well is flowing, then the well is shut-in for a given length of time. In a pumping well, it can be obtained by pulling the plunger and rods and running a bottom-hole pressure bomb inside the tubing. Sometimes, it also may be necessary to pull the tubing and bail or swab the well down before running the pressure bomb.

Pressure buildup curves. As an illustration, there are shown on the chart of Fig. 2 buildup curves on two different wells, plotted in a manner as described in "How Well Completion Damage Can Be Determined Graphically," *(World Oil,* April, 1955). Both wells have a pay section 20 ft thick (h) and a formation permeability of 1 millidarcy (K). Both wells were producing at the rate of one barrel of oil per day (q) when shut-in for the buildup survey.

Notwithstanding these similarities, Well B should be considered a poor candidate for workover, while the buildup survey reveals that Well A should be a very good prospect.

The trouble with Well B, as diagnosed by the build up curve, is lack of formation pressure (only 300 psi static). The completion factor of 70 per cent is quite satisfactory and could possibly be improved only to a minor extent by stimulation.

Well A, on the other hand, shows adequate formation pres-

NEVER LOST A DROP!

ENGINEERED LOST CIRCULATION CONTROL!

- **GRADED**
- **GRANULAR**
- **HIGH STRENGTH**
- **INCOMPRESSIBLE**

Effective seals in

Fractured Zones • Vugular Limestones • Unconsolidated Formations

Available through your mud and cement service companies

CHEROKEE LABORATORIES, Inc.

HOME OFFICE AND MANUFACTURING PLANT IN TULSA, OKLAHOMA
Branches: Midland, Beaumont, Corpus Christi, Oklahoma City, New Orleans, Lafayette, La., Casper
EXCLUSIVELY LICENSED BY STANOLIND OIL & GAS COMPANY

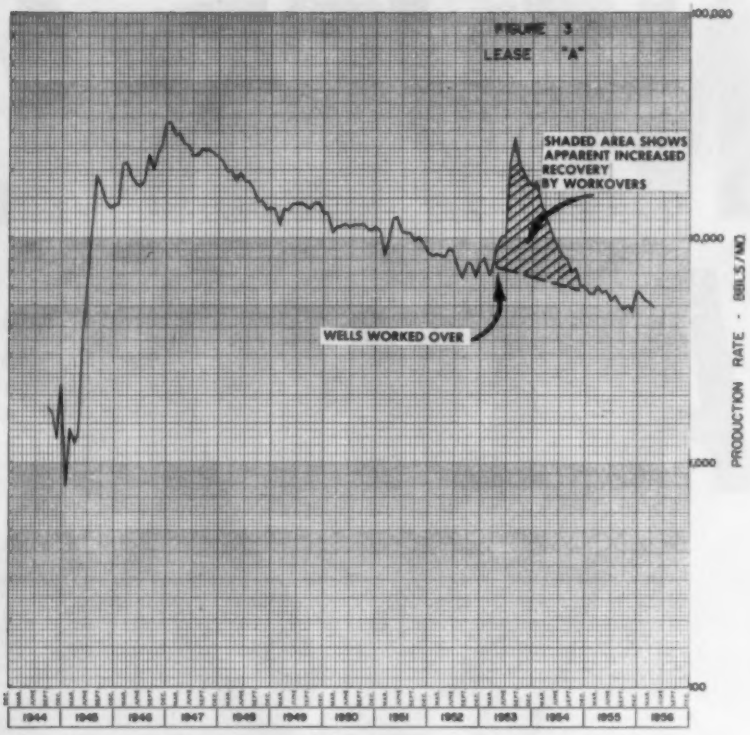


FIG. 3. **Production rate versus time** curve may make it appear that the workover job was highly successful. Shaded area under curve shows apparent increased recovery due to workover.

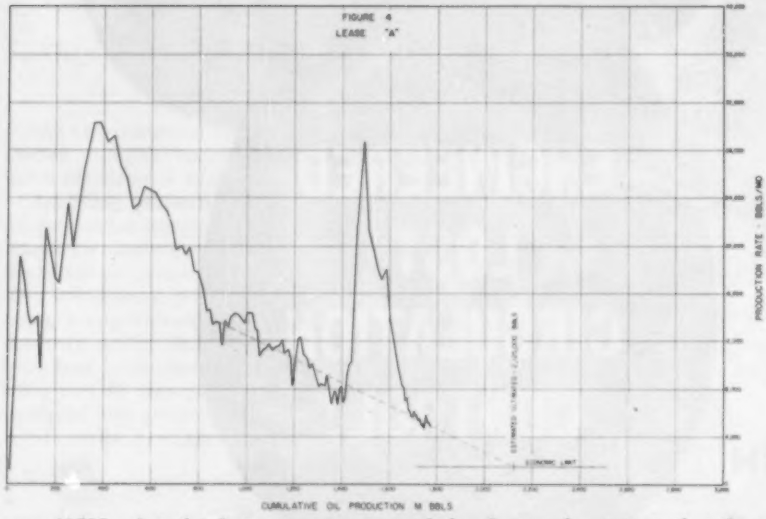


FIG. 4. **Rate versus cumulative** curve of same production data taken from Fig. 3 and plotted on coordinate paper demonstrates that no additional oil will be recovered ultimately. In this case, the workover campaign was not considered successful.

sure (1500 psi static) but a very poor completion factor of 10 per cent. This is caused possibly by sanding-up, paraffin deposition, salt deposition, plugging of perforations, or any other cause which would increase the skin effect around the well bore. Stimulation treatment such as fracturing, reperforating or acidizing stands a good chance of removing the cause of low productivity and raising the completion factor to 100 per cent or better, thus turning the well into a commercial producer.

Economic analysis. Before such a workover can be approved by management, an economic analysis usually is provided by the engineering department. Such an analysis sets out the expected cost of the job together with its anticipated results. In the normal course of events, the results in terms of dollars have to make a fairly good showing when compared to the cost in terms of dollars. **Payout alone is not sufficient.** Besides returning the investment, the operator expects that the expenditure made also earns an additional profit on his money.

One of the common fallacies in an economic analysis of this kind is that usually only the results of a successful stimulation treatment are considered and not enough weight is given to the fact that not all workover jobs prove to be successful.

Management often finds it necessary, therefore, to introduce a safety or risk factor in the calculation, based on past experience, or, conversely, raise the minimum profit required before approval is granted.

Evaluating Workover Results

After a well workover has been performed, it is helpful in planning similar work in the future to periodically make an analysis of the results. These so-called "post mortems" are often very instructive.

ECONOMY

CLIMAX

IN TEXAS

Davidson Drilling Company has used Climax Blue Streak Engines for years. They know, and have proved, that for positive, reliable power Climax is the answer.

IN LOUISIANA

Grey Wolf Drilling Company depends on Climax Blue Streaks for steady, reliable power. They know from experience that they can count on Climax's instant throttle response, fast acceleration and heavy duty performance.

In the oil industry, as in every other, first consideration is given equipment that will operate economically, day in and day out. Above are two typical examples of how producers everywhere are turning to Climax Blue Streak economical power. Economy, dependability, and positive power make Climax your best buy. Call your nearby Climax distributor — there is one within a few hours of your location — and let him solve your power problems.

WHERE POWER IS YOUR PROBLEM—CLIMAX IS THE ANSWER

climax BLUE STREAK ENGINES

CLIMAX ENGINE AND PUMP MFG. CO.

208 SO. LA SALLE ST. CHICAGO 4, ILL.

FACTORY
CLINTON, IOWA

•

DISTRICT OFFICE
155 CONTINENTAL AVE.
DALLAS 7, TEXAS

DISTRIBUTORS

SALES AND SERVICE

Drillers Machine Shop
Oklahoma City, Okla.

General Diesel and Equipment Company
(Formerly Sweeney Bros.)
Williston, North Dakota

Wilson's Engine & Equipment Co.
Bakersfield & Long Beach, Calif.

Stewart & Stevenson Services, Inc.
Houston and 5 Texas Branches

Cullander Machinery Co.
Belzoni, Miss., & West Memphis, Ark.

Tobin Machinery Co.
Lafayette, La.

Vern Walton Co.
Coolidge, Casa Grande & Marana, Ariz.

Landes, Zachary and Peterson
Denver, Colo., & 5 Branches

United Power, Inc.
(Formerly United Tool Co.)
Shreveport & Alexandria, La.

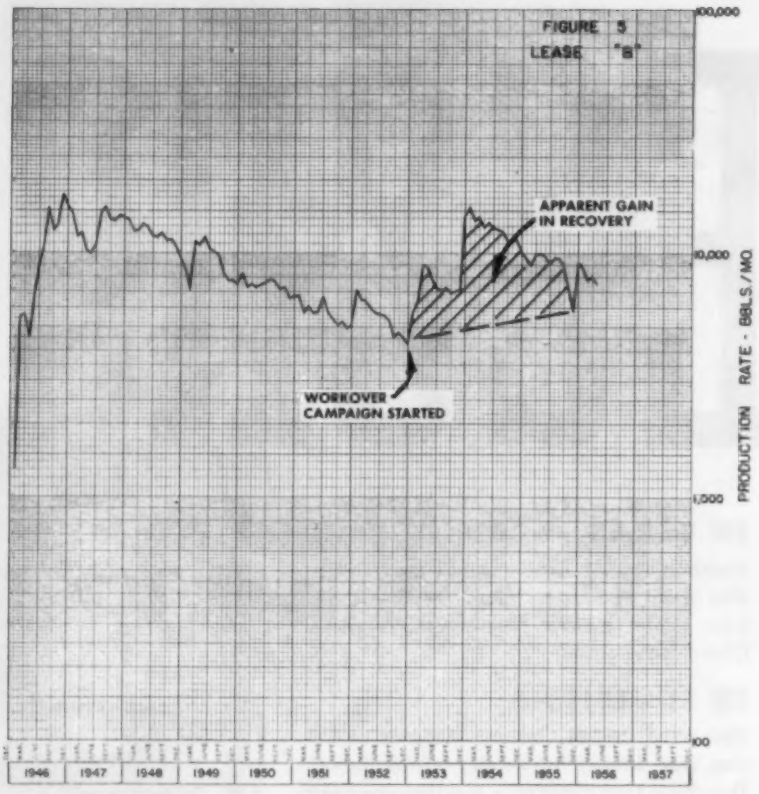


FIG. 5. **Workover campaign** appears successful in this rate-time curve. The shaded area represents the apparent gain in oil recovery. Fig. 6 shows how this campaign was evaluated.

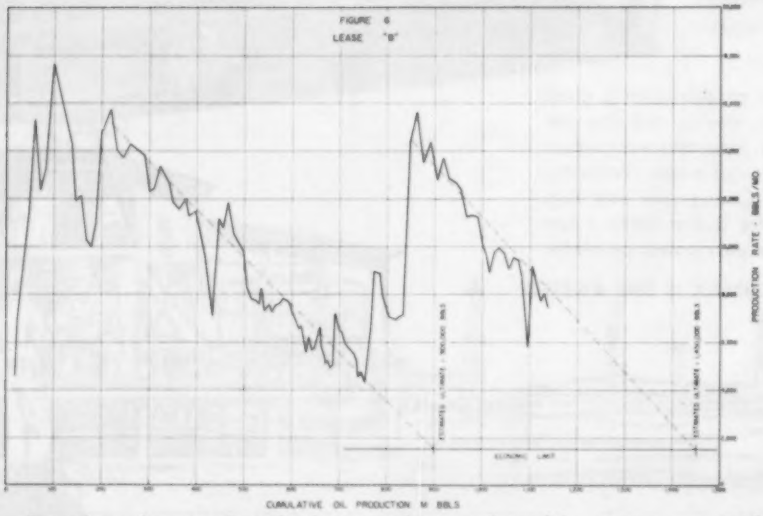


FIG. 6. **Characteristic curve of a successful workover** when same data shown in Fig. 5 are plotted on rate-cumulative basis. Note that the ultimate anticipated recovery has been materially increased.

Sometimes the rate of production may show a substantial increase, and if plotted as a rate-versus-time curve it will appear like a very successful venture. An example is attached hereto as Fig. 3.

The production rate from this lease after a number of workovers increased from 6800 bbl per month to 27,800 bbl per month, but the production declined at a much faster rate after reaching its new peak than it did before.

Normally, such a result would be considered as a successful workover campaign. However, if these same data are plotted on a rate-cumulative chart as shown on Fig. 4, it will be noted that actually no new oil was gained, since after passing its peak the lease is back down on the same trend as it was before, and the same cumulative is reached with the same production rate and the same decline. Some of the oil, of course, was produced faster and at a higher rate, thereby bringing about a saving in operating costs, but it is doubted if this alone made the venture worthwhile.

What a successful workover looks like. On the chart of Fig. 5 is shown another example where the production rate increased after a certain amount of remedial work from 4250 bbl per month to 15,500 bbl per month, and where the rate-cumulative relationship of Fig. 6 proves that in this case a substantial and real gain in ultimate recovery was obtained.

These two examples serve to illustrate the common fallacy of taking every increase in rate as an indication of success.

A study of the rate-cumulative relationship is often necessary to see whether this success was real and to find out if in addition to producing some of the oil at a faster rate an actual gain in ultimate recovery was obtained. ★ ★ ★

no lost time tonight

At least not because the crew is waiting for Christensen diamond equipment. It's on hand—and, if needed, so is the Christensen Sales Engineer. His working knowledge of operating technique will gain the best possible results from these products.

This is Christensen service—the service you expect and get—when using Christensen diamond equipment.

These men are available from one of 33 sales offices and can draw on the facilities of four manufacturing plants.

Get the right equipment for the job at the right time—and if needed the knowledge of a Christensen Sales Engineer—it'll mean "Less Cost Per Foot."

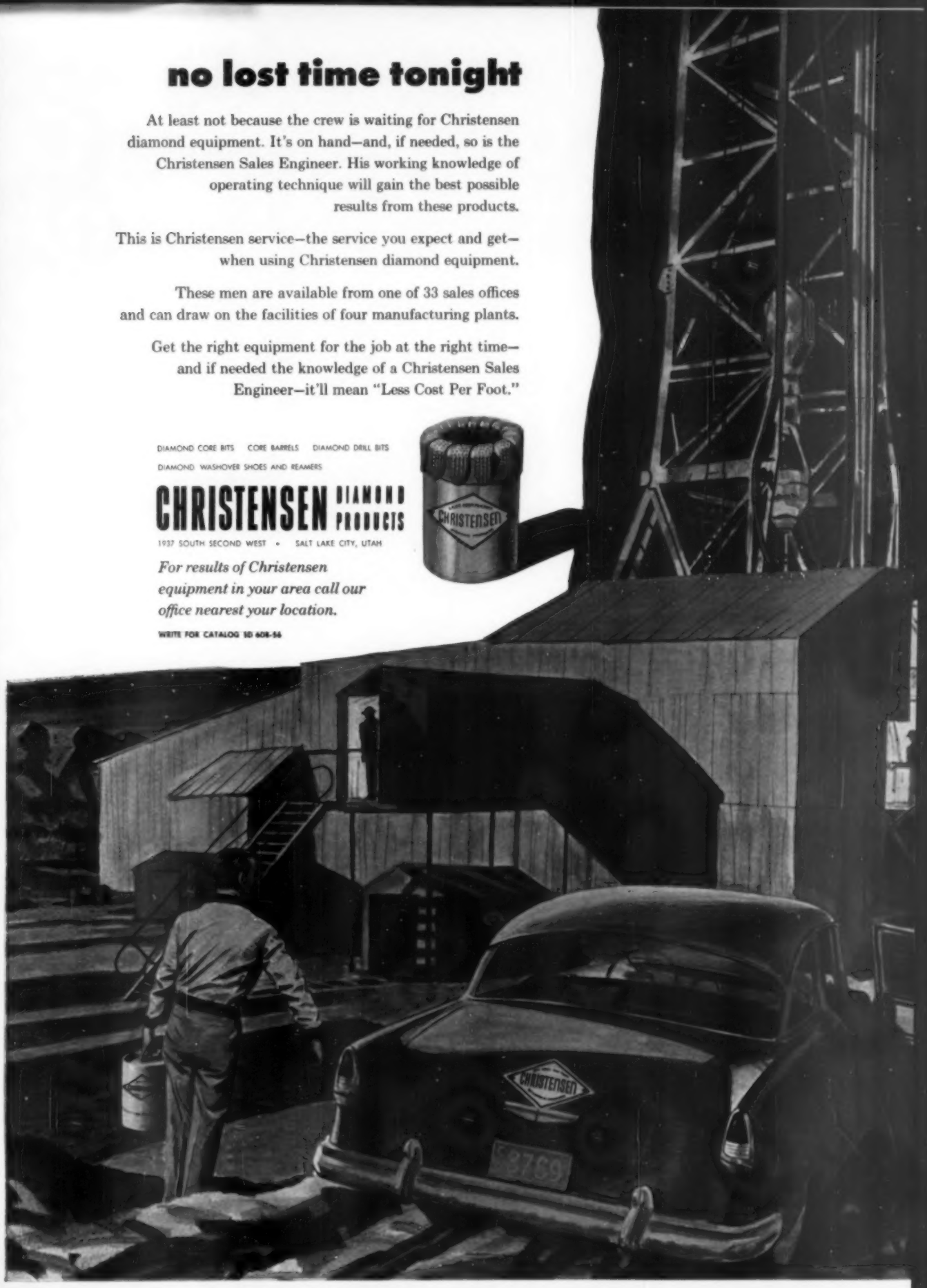
DIAMOND CORE BITS CORE BARRELS DIAMOND DRILL BITS
DIAMOND WASHOVER SHOES AND REAMERS

CHRISTENSEN DIAMOND PRODUCTS

1937 SOUTH SECOND WEST • SALT LAKE CITY, UTAH

For results of Christensen equipment in your area call our office nearest your location.

WRITE FOR CATALOG SD 608-56



Announcing our new line of

GAS LIFT EQUIPMENT

We are pleased to announce the addition of Otis Gas Lift Equipment and Services as part of the general expansion of our line of tools and wire line facilities. Through the acquisition of the Bryan Gas Lift Company of Fort Worth and Cummings, Inc., of Houston, Otis now offers the most advanced gas lift equipment on the market – exclusive features not available in any other systems.

Our customers also receive the combined experience of the oldest gas lift company and the oldest pressure control company in the oil industry – more than 50 years of gas technology.

Look to Otis, too, for other new tools and services. We are undertaking the largest expansion program in our history – in Research, Engineering, and Manufacturing – to keep Otis "First in Pressure Control."

OTIS PRESSURE CONTROL, INC.

Branches Throughout the Oil Country

Otis – "first in pressure control"

SPECIAL Well Workover FEATURE

Workover Problems and Their Solutions

Here are some of the problems common throughout the industry and some of the best solutions to these problems. Many times a problem well may have a combination of these "ailments."

C. J. Rodgers
Gulf Oil Corporation, Houston, Texas

PROBLEM: Casing Leaks (and Collapse)

Causes: Casing leaks may be caused by corrosion; excessive internal wear by tubing, drill pipe, or tools; improper functioning of artificial life equipment; and joint failure. The welding of scratchers and centralizers onto the casing has also been suspected as another reason for leaks.

The most common of the leaks due to corrosion is that resulting from failure to protect the outer side of the casing from corrosive fluids. Repeated round trips and prolonged rotation of tubing and drill pipe will cause excessive internal wear in the casing and can result in leaks. In pumping wells, the reciprocating movement of the tubing which is caused by the action of the pump will subject the casing to wear and may cause a leak. Malfunction of gas lift equipment can lead to gas jetting against the wall of the casing causing a leak.

There are a number of causes of leakage or failure at the casing joint of which the three most important are: (1) Uncorrected damage to the threads — either before or during casing make-up; (2) Improper casing make-up (cross-threading, etc.); and, (3) Excessive tension on the casing string. The latter occurs when the casing is in tension and unsupported by the cement. This can cause a threaded end to pull out of the coupling.

One of the primary causes of casing collapse is movement of the beds penetrated by the cased hole. This is not unusual in those areas where production is obtained from unconsolidated sands, particularly after large volumes of sand have been produced with the well fluids. Another cause of collapse is the inability of the casing to withstand the external pressure differentials to which it is subjected. (Casing has also been burst by excessive internal pressures.)

Solutions: Trouble from casing leaks can be costly. They may lead to encroachment of undesirable fluids and substances into the well bore. It is also possible that oil and/or gas from the productive zone may be lost, if other formations are opened to the well bore as a result of the casing leak. Collapsed casing may restrict or prohibit producing the well.

When such conditions are known to exist, it is imperative that corrective and remedial measures be undertaken. After the damaged section of casing has been located several methods of repair are possible:

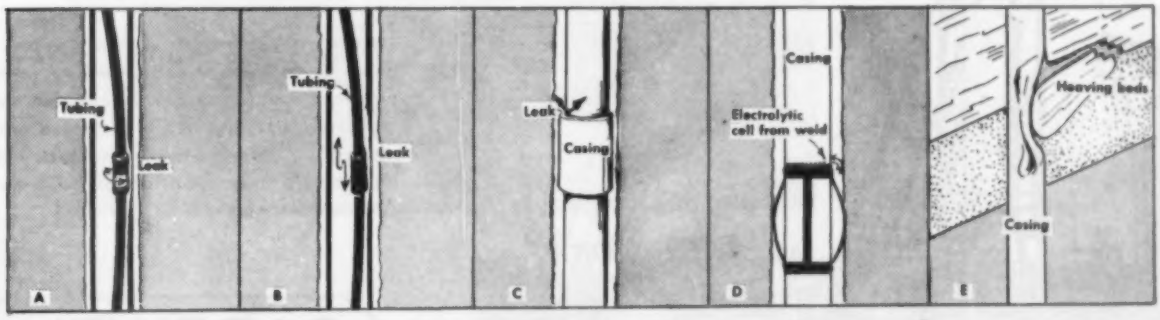


FIG. 1. **Causes of casing leaks:** A. Rotation of tubing collar against casing wall. B. Reciprocation of tubing collar against casing wall. C. Improper thread make-up can cause leak in threads. D. Welding centralizer to casing can cause electrolytic cell, and leak from corrosion. E. Shifting beds can cause casing collapse.

this *new* CARDWELL

* P.T.O. Driven
* Trailer Mounted
* Truck Mounted

What do YOU need in a servicing hoist . . . fast operating speeds . . . minimum weight without sacrificing strength . . . greatest versatility in mounting . . . rugged, yet precision construction?

Then, this Model K-200 Series fits your every requirement. These 7,000 to 9,000-foot single or double drum hoists are the result of 30 years' experience building servicing equipment that best meets the industry's specifications.

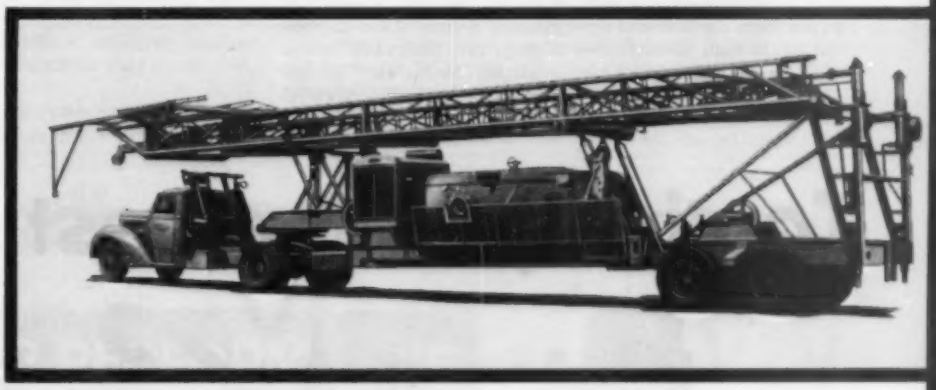
Write for complete information and prices on a hoist to fit your needs, or see your nearest Cardwell representative.

Here are the Cardwell design features that mean *Top Performance:* convenient air controls, air-friction-clutch driven throughout, including drum drives, and water-cooled braking system. Optional equipment: rotary drive assembly, and single or double leg masts or tubular steel masts.

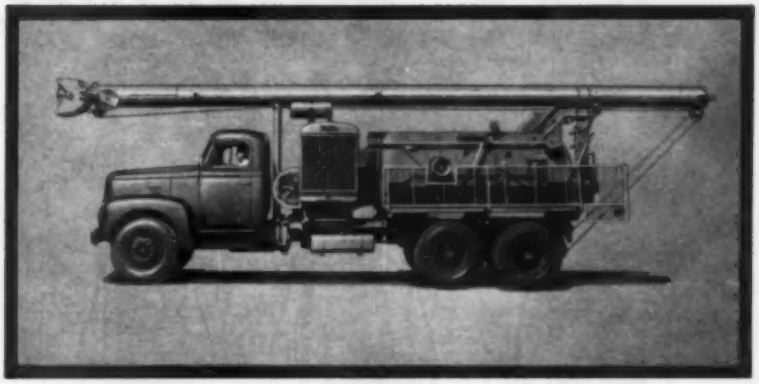
CARDWELL

Hoist will fit your every need

Power take-off K-201 holds axle loads to a minimum.



K-200 with 89-foot, 150,000 lb. capacity "Trailermast". Easy to transport and rig-up.



Truck-mounted K-200 is available with engines up to 230 H.P. to give maximum power and operating speeds.

CARDWELL MANUFACTURING COMPANY • Box 2001, Wichita, Kansas, U. S. A.

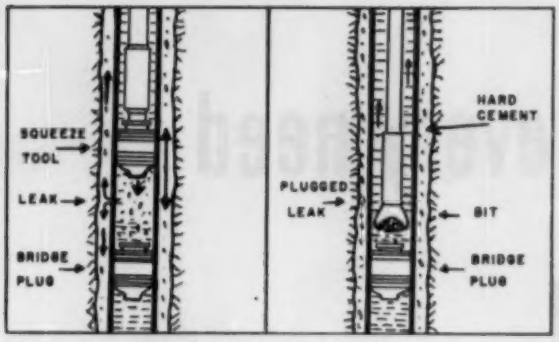


FIG. 2. **Squeeze through leak** to repair casing. The bridge plug should be near leak to minimize the amount of casing exposed to high squeeze pressure.

SQUEEZING

One method of repairing a casing leak, once it has been located, is to squeeze with cement, plastic, or one of the cement-oil mixtures. In certain areas some of these materials have been found to be more successful in sealing leaks than others.

If the squeeze tool-bridge plug combination is used in locating the leak, these tools would also be used for the squeeze operations. The bridge plug, however, is usually reset near the bottom of the leaky section to prevent exposing any more of the casing string to the squeeze pressure than is necessary.

If a single packer is used to locate the leak, it would be pulled from the hole and a plug placed slightly below the bottom of the leak. Several types of plugs have been used: *bridge plugs, gravel capped with plastic, plastic, cement, etc.* The type used depends on the depth and location of the leak with respect to the producing interval and, of necessity, economics. After the plug is placed a squeeze tool is run back in the hole.

The sealing material, cement, plastic, etc., is placed through the leak and around the outside of the casing by the squeeze technique. However, the final squeeze pressure is usually low when compared to that normally applied at conventional squeeze jobs. The squeeze pressure applied to seal the leak need not be more than the lesser of (1) the burst strength of the casing, and (2) the maximum producing formation pressure that could be applied at that point.

After waiting sufficient time for the sealing material to harden and set, it is drilled out and the squeezed section pressure tested to confirm that the leak has been effectively repaired.

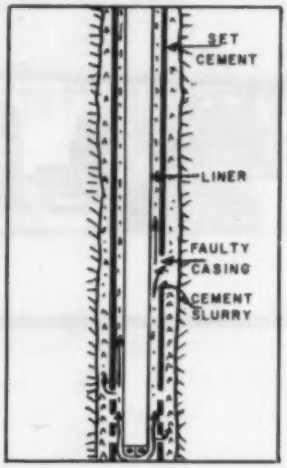


FIG. 3. **Install a liner** where the casing is large enough. The liner is hung from the surface and cemented in the same manner as original casing.

To give you the best service

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

INSTALLING INSIDE STRINGS AND LINERS

In high pressure wells, if the well casing is large enough, an inside string may be set and cemented to remedy the leaking condition. Short liners have been suspended from the well head and hung on a packer to seal against a leak in shallow, low pressure wells.

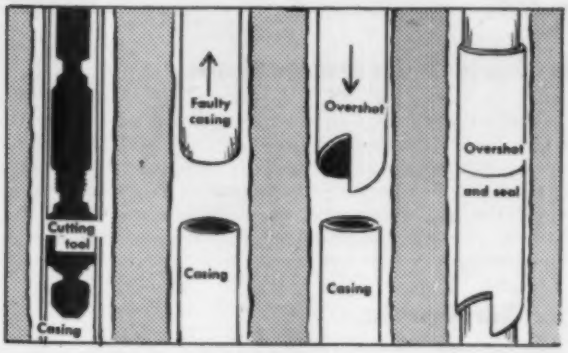


FIG. 4. **Faulty casing is cut** below leak, removed from the hole and repaired casing re-run. A special overshot type seal connects the two pieces of casing.

CUTTING, REMOVING, AND REPAIRING CASING

In some cases it is possible to cut the casing in two below the leak, recover the upper section, replace the damaged section and seal it to the lower part of the casing string. This type of leak repair is particularly adaptable to relatively shallow depths. Corrosion leaks caused by brackish waters are commonly repaired in this manner.

After a leak is located, a plug is set in the casing a short distance below the leak. The casing is cut in two below the leak, pulled, and recovered. A trip in the hole is made to remove any burrs from the top of the cut section and to condition the walls of the hole. The damaged section of casing is replaced. The upper section of casing is run back in the hole with an overshot type seal on bottom for latching onto and sealing to the lower section of casing. Cement, plastic, or one of the protective mixtures is usually pumped behind the upper section of casing before it is sealed to the lower section.

A recent development in tools of this type permits the casing to be cut below the leak; the casing above the cut point stripped over the drill pipe that remains engaged to the lower section of casing; and the upper section, which has had the faulty casing replaced, stripped back over the drill pipe. This

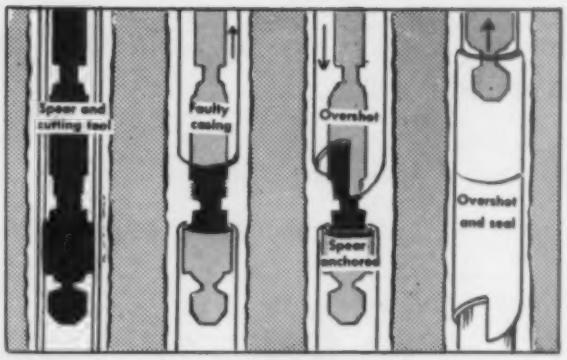


FIG. 5. **A combination spear and cutting tool** eliminates difficulties sometimes experienced in latching back onto casing in the hole. The spear holds the lower section of casing after cut, and the upper portion is stripped out of the hole over the drill pipe. Repaired casing is re-run and sealed onto lower portion and the spear removed.

...under all conditions

CENTRALIZER PERFORMANCE

The painstakingly engineered design of Larkin Centralizers has provided the oil industry with a product that exceeds every known requirement for centralizer performance . . . performance that has been verified and certified* by an unbiased testing laboratory.

And the field results . . . now proved again in hundreds of applications . . . have shown that Larkin Centralizers will meet any demand: • Convenience of installation • Ease of starting • Maximum centering force • Minimum permanent set • Economy

Larkin offers a complete selection of Casing Centralizers, in Long or Short Lok-On or Slip-On Types with five ranges for maximum efficiency. Specify Larkin "through your supply store." You'll get the best service under all conditions.

LARKIN PACKER COMPANY, INC.
WAXAHACHIE, TEXAS

LARKIN
...Through Your Supply Store

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

technique assures that the lower section can be readily engaged by the upper section when run back in the hole.

OTHER REPAIR METHODS

Collapsed casing may be restored to nearly its original size and roundness by the use of a casing roller, if the degree of collapse is not too great. For those cases where the casing is badly collapsed, it is usually more economical and sometimes the only alternative to side-track, drill the necessary hole, and set a liner.

PROBLEM: Excessive Sand Production

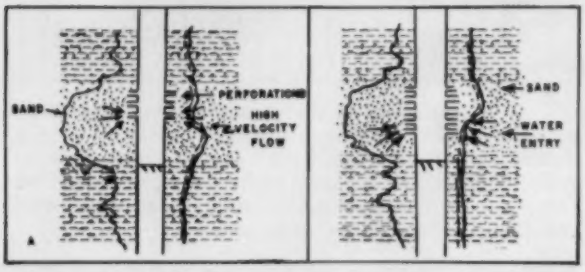


FIG. 6. **Two of the causes of sand production:** A. High velocity through perforations in unconsolidated sand section. B. Water production washes cementing materials from unconsolidated oil sand.

Causes: Wells that produce from unconsolidated sand formations are often troubled by sand encroaching into the well bore. This sand migration is initiated by the velocity of the incoming fluids which erode and carry the sand particles into the well bore. Small quantities of sand can usually be tolerated; however, any sizeable sand production will damage the producing equipment and increase lifting costs. Continued migration will eventually cause the well bore opposite the producing section to be filled with solids and production from the well to be restricted or completely stopped. Unconsolidated sand formations contain considerable shale and silt, and continued migration of the sand particles will allow shifting or moving of the formation opposite and adjacent to the point where fluid enters the well bore. This can result in the well's becoming sanded up and could possibly damage the casing. Steeply dipping beds will accelerate this, since there is an inherent tendency of the sand beds to slough into the well bore.

The encroachment of formation waters will cause a change in the composition of the produced fluids from oil to oil-water and may permit unfavorable chemical reactions such as dissolving the cementing material within the unconsolidated sands. The large volume of fluids usually produced after water encroachment also increases the rate of erosion caused by the higher velocity of fluid into the well bore.

Solutions: Various means have been used in attempts to prevent encroachment of sands into the well bore. Basically, however, they have been either mechanical or chemical. Of the two, mechanical measures have been the cheaper and usually the simpler to apply, and, as a result have had more widespread use.

The mechanical devices used to impound or restrict encroachment of the sand grains are perforated pipes, slotted pipes, wire-wrapped screens, prepacked filters, and gravel packs. Wire-wrapped screens have been used in greater numbers than the other types, and since 1949 gravel pack completions have been increasing in number.

GRAVEL PACKING

Several methods of gravel packing are used. The most popular today is pressure pack technique.[1] In essence this is the placing of gravel in and adjacent to the producing formations with fluid pressure and by the use of a drill fluid that will permit partial or complete loss of returns to the formation during placement. This technique of gravel packing has been very successful in preventing or retarding the migration of sand into the well bore. Pressure pack gravel packing is especially suited for but not limited to those well completions in which the casing is cemented through and opposite the producing sand body, and the casing and cement sheath are perforated to allow drainage of fluids from the sand into the well bore.

Before beginning gravel pack operations, the sand face

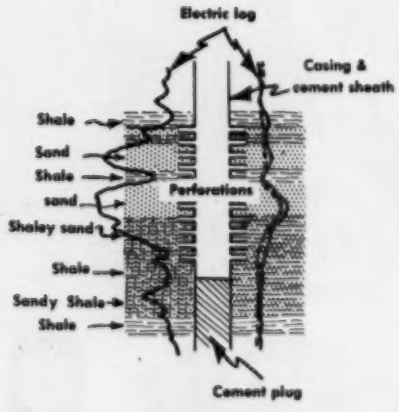


FIG. 7

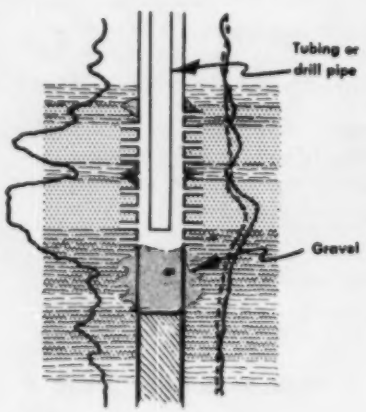


FIG. 8

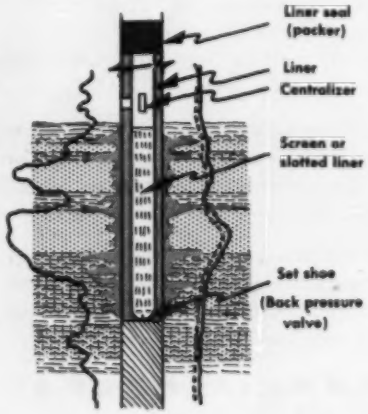
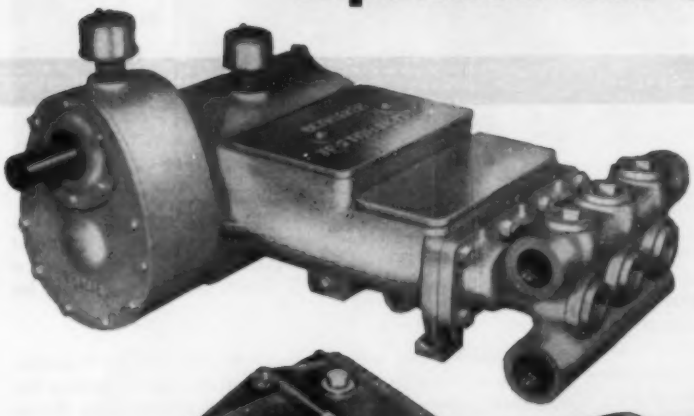


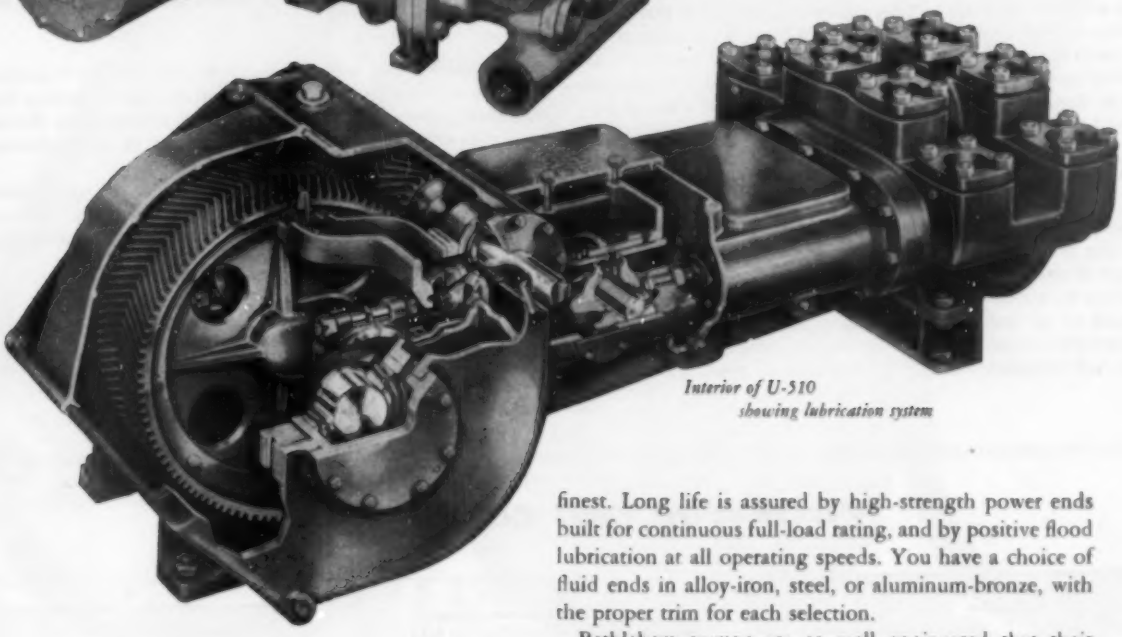
FIG. 9

FIG. 7. **Section of the well to be gravel packed.** Note the stratification of sands and shales as shown in electric log. FIG. 8. **Gravel is pumped down tubing** with salt water after sand face has been cleaned. By applying fluid pressures and reciprocating tubing, gravel is forced through the perforations against the sand face and along the bedding planes. FIG. 9. **Screen and liner are washed down** through the gravel left in the casing.

Pick your "Handy Man" from this expanded line of power pumps



TP-3 Triplex Pump



Interior of U-510 showing lubrication system

Bethlehem now offers five distinct sizes of general-service pumps, so that it's even easier to pick just the right unit. We doubt that you've ever seen a line of pumps with so much versatility. Each is a "handy man"—a pump that can readily be adapted for several different kinds of work.

Does your job involve waterflooding? Salt-water disposal? Pumping crude oil in gathering systems or pipe-line service? Pumping mud or water for the drilling rig? If the answer is yes, there are Bethlehem units that will fit perfectly into your engineering plans.

You can bank completely on the quality of these pumps. Components are exhaustively tested. Materials are the finest. Long life is assured by high-strength power ends built for continuous full-load rating, and by positive flood lubrication at all operating speeds. You have a choice of fluid ends in alloy-iron, steel, or aluminum-bronze, with the proper trim for each selection.

Bethlehem pumps are so well engineered that their salvage value is always high. We feel certain that their many advanced features will interest you. If you will write or call, our people will gladly furnish complete information.

FIVE SIZES, DUPLEX AND TRIPLEX

Model	Type	Plunger Load, lb	Input Hp	Bore & Stroke, in.
U-33	Duplex	2400	14 @ 180 rpm	1¾ to 3 x 3
UA-46	Duplex	5000	40 @ 120 "	2½ to 4 x 6
U-510	Duplex	12000	100 @ 75 "	3 to 5½ x 10
TP-3	Triplex	3580	22.4 @ 250 "	1¾ to 2¼ x 3
TP-4	Triplex	5000	42 @ 250 "	2 to 4 x 4

BETHLEHEM SUPPLY COMPANY

General Offices: 21 E. Second St., Tulsa, Okla.
West Coast Headquarters: Los Angeles, Calif.
Export Distributor: Bethlehem Steel Export Corporation
25 Broadway, New York, N. Y.

BETHLEHEM SUPPLY

should be cleansed of foreign materials by swabbing, bailing, or washing. A saline or nonaqueous, nonsolids drill fluid should be used. Gravel is put in the well bore by pumping a placement fluid, (usually salt water) containing gravel down open-ended tubing or drill pipe bottomed opposite the perforated interval. By applying fluid pressure and reciprocating the tubing, gravel is forced through the perforations against the sand face, along bedding planes, and in any fractures that may exist or that may be caused to occur in the formation. The placement fluid is either lost to the sand body or returns to the surface through the annular space between the tubing and casing. During squeezing operations the fluid is lost to the formations. Gravel is placed in this manner until the well bore and formation have been packed to the desired fluid pressure. After placement of a quantity of gravel in the well bore to cause a fill-in above the top of the perforated interval, additional gravel is placed in the well bore. This is done so that after the screen liner is positioned, gravel fills the annular space between the liner and casing. The tubing or drill pipe is removed from the hole after the gravel is placed, and the screen liner assembly is made up, run in, washed in place, and released. The customary tubing setting is made for completion.

Several modifications of the pressure pack technique of gravel packing have been made; such as, the use of squeeze tools during the placement of the gravel, and various prepared fluids which are used as a carrying agent for the gravel.

PACKING WITH PLASTIC COATED WALNUT SHELLS

The most recent development in sand control technique is plastic-walnut shell treatment.[2] This treatment consists of injecting ground and graded walnut shells (usually 20 to 30 mesh in size) coated with unset plastic into the producing formation by means of an oil type carrier fluid. The plastic is allowed to set and thus consolidates the walnut shells into a permeable screen. The mass inside the casing is drilled out and the well completed in the conventional manner.

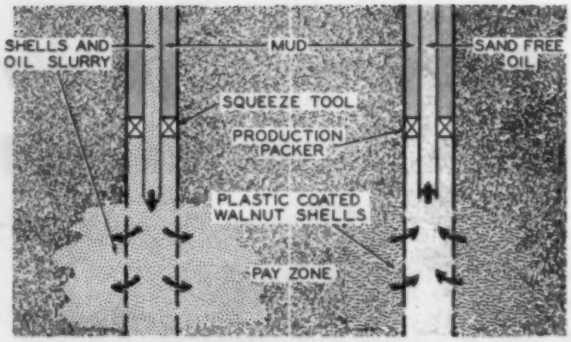


FIG. 10

FIG. 10. **Plastic coated walnut shells** in an oil-carrying agent are injected under pressure into the incompentent sand formations (left). When the plastic sets, the shells form a consolidated network, through which sand-free oil can be produced (right).

The placement of the plastic-walnut shell mixture is usually done through and below a squeeze tool in order to confine the placement pressure. Two or more stages or treatments should be used in order to insure complete coverage of the producing section.

This technique is particularly applicable to the upper zone of a dual completion, since "inside strainer settings" are not necessary to hold the walnut shells in place outside the casing. It is also applicable to wireline workovers.

References

1. Rodgers, C. L., "Some Practical Aspects of Gravel Packing," *Journal of Petroleum Technology* (Jan. 1954), pp. 41-47.
2. Henderson, J. K.; Saller, W. L.; and Stout, C. M., "A New Method for Controlling Incompetent Sands," presented at the Fall Meeting of the Petroleum Branch, AIME, October, 1955.

PROBLEM: Bad Cement Jobs

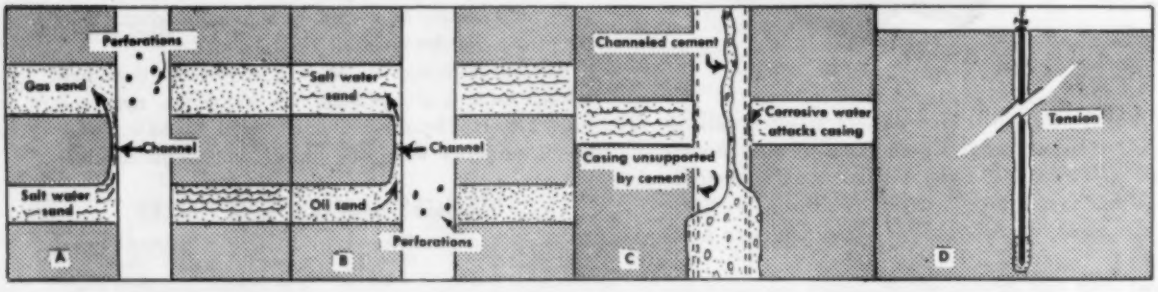


FIG. 11. **Effects of bad cement jobs:** A. Salt water channels up casing into oil sand. B. Oil and gas channels into salt water sand. C. Corrosive water attacks casing which should have been protected by cement. D. Casing fails in tension because it is not supported by cement.

Causes: **A combination of three undesirable effects may come as a result of a bad primary cement job: (1) The cement behind the casing may fail in preventing movement of fluids from one zone to another behind the casing; (2) It may fail to protect the casing from corrosive fluids; and (3) It may fail to adequately support and reinforce the casing.**

The prevention of fluid movement behind the pipe is the primary purpose of cementing casing in the bore hole. All vertical movement of the fluids in the hole must be restricted to the inside of the casing. Should the cement job fail in this respect great damage may result. Undesirable fluids may invade the producing formation by channeling behind the casing, and there is also the possibility of losing oil and/or gas from the producing zone to formations with less pressure.

There's a Green Triangle rotary hose for every application !

NEW YORK BELTING & PACKING CO. • Founded 1846

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company
General Offices: DALLAS, TEXAS
Representatives in All Principal Oil Fields of the World

CONTINENTAL
Serving the Oil and Gas Industries

From the smallest to the largest rigs, there's a Green Triangle Rotary Hose. The greater strength and flexibility of a Green Triangle Hose assures the ultimate in performance. Another advantage: Ready availability . . . through your Continental Store.

Continental Supply Company stocks a complete line of New York Belting & Packing Company oil field rubber products.

serving the industry with the best...

BRODERICK & BASCOM has always brought the industry the best wire rope available with their complete line of Yellow Strand.

Now available, through your Continental Store, is the latest achievement in wire rope construction... "POWERSTEEL." Its higher strength gives much more in ton-mile service at a small additional investment.

Ask a Continental man about

Yellow Strand® "POWERSTEEL"

CONTINENTAL

Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: DALLAS, TEXAS

Representatives in All Principal Oil Fields of the World

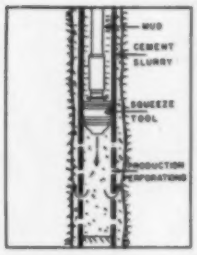


FIG. 12

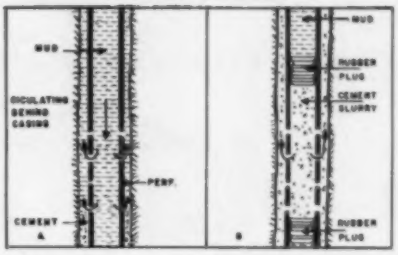


FIG. 13

FIG. 12. **Repairing cement** job through production perforations. FIG. 13. **Two steps in repairing** cement job where circulation can be established behind casing: A. After casing is perforated, circulation established in annulus between bore hole and casing. B. Cement enclosed between two rubber plugs is pumped down the hole and up on the outside.

Failure of the cement to adequately support and reinforce the casing makes the well more susceptible to mechanical damage during production operations. The lack of support can cause leaks and, of course, if corrosive fluids such as sulfur waters are present, the outer wall of the casing is continually attacked by corrosion.

Solutions: Remedial operations to correct a bad cement job can be compared to repairing a faulty construction job. In this case the repair work consists of placing a sealing and reinforcing material, i.e. cement, plastic or one of the cement-oil mixtures, around the outside of the casing opposite the formations to be sealed off. This material should also be placed around that section of the pipe which requires maximum burst or collapse strength.

There are a number of ways to determine whether or not a cement job is satisfactory. If a temperature survey is made shortly after primary cementing, the heat generated by the hydrating cement will be recorded. The survey will indicate the top of the cement column outside the casing and may also give an indication of the vertical continuity of the cement column. If the findings of the temperature survey are compared to the calculated fill up of the cement column, then it can be ascertained if a *"good"* or *"bad"* cement job was obtained. Bad cement jobs are also suspected when the production performance of a well is contrary to what should be expected because of the performance of other wells completed in the reservoir and the information available concerning the reservoir and structure.

If a completion has been attempted before the bad cement job is detected or suspected, it may be possible to place the repair material through the completion interval to the desired position outside the casing. If there are no outlets in the casing through which placement of cement, plastic, or other repair material can be made, it will be necessary to perforate the casing. Only a short section of casing (usually two feet) needs to be perforated for this purpose. It may be possible to circulate down the inside of the casing and up the casing-open hole annulus.

If circulation is easily established and maintained, the placement of the selected material can be accomplished by the pump down — plug method similar to that used in primary cementing. The material chosen for the repair is confined between rubber plugs and pumped down the inside of the casing and up the casing-open hole annulus. The repair material is circulated to the desired position or height outside the casing and allowed to harden and become set. During this time, the material is held immobile by balancing the fluid columns in and outside the casing or by holding pressure on the upper plug that is stopped some distance above the perforations or outlet from the casing. The casing is drilled out, and the perforations or the outlet from the casing are pressure and/or dry tested when the material has set. If these tests are satisfactory the customary completion can be made.

If circulation down the casing and up the casing-open hole annulus to the surface cannot be established, it will be necessary to resort to block squeezing opposite the formations to be isolated and that part of the casing to be protected and reinforced. For example; perforations, usually two-foot sections, are made below and above the interval selected for completion. These perforations may be squeezed individually. A retainer type squeeze tool should be used for the lower perforations so as to eliminate the necessity of drilling out. A retrievable squeeze tool would be used for the upper perforations. The cement, plastic, or other material inside the casing and opposite the upper perforations is drilled out and a pressure and/or dry test made to test the effectiveness of the squeeze. If no additional repair work is necessary the completion can be made.

If the perforated intervals above and below the section of the casing to be isolated, protected or supported are a relatively short distance apart they can be squeezed simultaneously. A retrievable squeeze tool should be used, the squeeze material inside the casing drilled out to a point above the lower squeezed perforations (if the completion is to be made above this point), and a pressure and/or dry test made. If the test is satisfactory and no further repair work is required, then the completion may be made.

It is sometimes considered advisable before two perforated intervals are squeezed simultaneously as described above to wash outside the casing between these intervals. This may permit a more uniform placement of the repair material around the casing between the two perforated intervals. The washing is accomplished by setting the squeeze tool between the two sets of perforations and establishing circulation down the tubing (or drill pipe) — casing annulus, out the upper perforations, behind the casing, in the lower perforations and up the tubing (or drill pipe) to the surface. After adequate washing in this manner the squeeze tool is released, reset above the upper perforations, and the squeeze job performed.

Block squeezes may be performed successively up the hole according to the technique described above that is most applicable.

No doubt numerous other techniques can be devised and have been used to repair bad cement jobs, but the examples outlined above are presented as possible remedial measures that may be taken.

PROBLEM: High Gas-Oil Ratios

Causes: Wells completed in oil reservoirs may produce with high gas-oil ratios for a number of reasons: the completion interval is not isolated to prevent the migration of gas from other reservoirs; the completion interval was improperly selected and is positioned too near or overlaps and includes a gas zone; and, the vertical permeability of the reservoir rock is such that gas coning is possible at certain flow rates.

High gas-oil ratio wells are undesirable, because the energy of the gas being produced is not performing useful work in lifting oil to the surface. Continued production of such excess gas will result in a shorter flowing life of the wells in the reser-

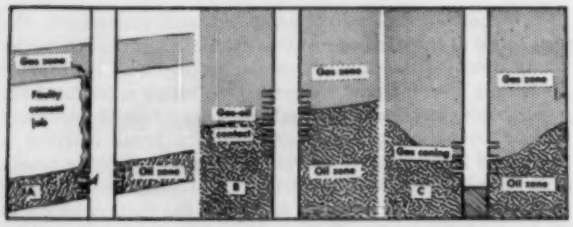


FIG. 14. **Causes of excessive gas production.** A. Migration from gas zone to oil zone via faulty cement outside casing. B. Improperly placed perforations straddling the gas-oil contact. C. Gas coning into perforated section.

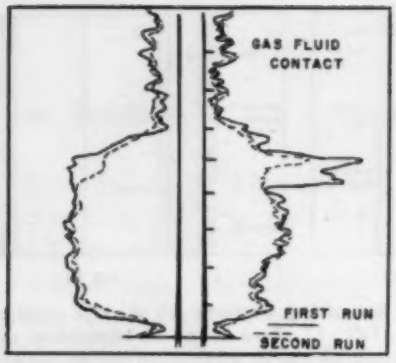


FIG. 15. **Gas and oil can often be distinguished** by response on the neutron curve of radiation log (at right).

voir and a reduction in the total oil recovery. Too, most regulatory bodies restrict or penalize the daily withdrawals from oil wells which produce with high gas-oil ratios, usually when the ratio exceeds 2000 to 1.

Solutions: The reasons for wells producing with high gas-oil ratios are such that a knowledge of the reservoir rock and fluids is desirable before remedial operations are begun. An analysis of the data obtained, while the well in question is being drilled, plus that data from other wells in the reservoir should confirm or rule out the presence of free gas in the reservoir. The production performance of any other wells completed in the reservoir should be analyzed.

If the producing (oil) reservoir did not originally have a gas cap and a well is producing with a high gas-oil ratio, it is reasonable to suspect that there may be communication between the completion interval and a gas bearing formation. However, gas caps have formed after production operations began, because a reduction in reservoir pressure liberated gas in solution.

The presence of free gas in a reservoir can usually be detected by the response on the Neutron Curve of a Radiation Log. In certain areas the Neutron Curve has been found to be a valuable tool in locating the gas-oil contact. Precise depth measurements are a necessity for the successful completion or recompletion of wells in reservoirs containing free gas. Correlation of the Gamma Ray-Neutron Survey, which has had the casing couplings located and marked thereon, with the Electric Log and Core data has been found to be most useful in depth measurement control in the completion of wells, particularly when the completion interval is near the gas-oil contact.

In some reservoirs it has been possible to note movement of the gas-oil contact by comparison of Neutron Curves made at different stages of reservoir depletion. This movement is, in effect, a shrinkage of the gas cap due to production of this gas, and it has permitted recompletions to be made at successively higher intervals within the producing reservoir when encroaching formation waters made them mandatory.

The remedial measures that may be undertaken in wells producing with high gas-oil ratio from oil reservoirs are limited. If a condition exists where excess gas is being produced and entering the well bore, from a source other than the producing formation, it can be corrected by cement squeezing and reperforating.

When the excess gas is free gas from the producing (oil) reservoir and the completion interval is below the gas-oil contact, it is possible that the excess gas is being coned downward into the well bore. If the vertical permeability is sufficiently less than the horizontal permeability, it may be possible to reduce the amount or prevent gas coning by a reduction of the producing rate. However, if the vertical permeability approximates the horizontal permeability, the flow rate necessary to maintain a permissible gas-oil ratio may be so low as to make this manner of producing uncommercial. If other wells are producing from the reservoir in question, a knowledge of their performance would indicate the possibility of such permeability conditions. However, if no other wells are producing from the reservoir, it is highly desirable that permeability measurements be made on representative core samples. When such permeability conditions are known to exist, i.e., the vertical permeability approximates the horizontal permeability remedial measures would not be warranted unless it is possible to increase the horizontal permeability by fracturing or pressure parting. The well can be produced at a restricted or penalized rate or be closed in until the oil zone is depleted by downdip wells.

There are cases in which the excess gas is free gas from the producing (oil) reservoir, and the completion interval is too near or overlaps into the gas zone. To prevent the production of such gas, the completion interval can be cement squeezed and the recompletion made below the gas-oil contact. A knowledge of the production performance of other wells in the reservoir and/or permeability data obtained from core analysis is desirable for this condition also. Reasonable judgment should be exercised in placing the upper limit of the recompletion interval near the gas-oil contact because of the fallacy of depth measurements.

PROBLEM: High Water-Oil Ratios

Causes: A well may produce with a high water-oil ratio if the completion interval is in or near a water zone or if waters foreign to the producing formation are allowed to channel into the completion interval. In some instances high water-oil ratios may be due to water coning. It is not uncommon in wells completed in stratified sands for the most permeable section to be depleted of oil before the other sand sections also open to the well bore. This may permit water to be produced from the depleted oil sand even though it overlies sand members containing clean oil.

Lifting costs are increased when salt water is produced because of the necessity for treating and disposing of the water, possible need of artificial lift equipment, and aggravation of corrosion problems. The complete elimination of salt water production is not always possible or necessarily desired. In the later stages of depletion of water drives reservoirs it is usually essential that the formation be flushed with water in order to sweep as much oil as possible into the well bore. This would

You benefit most when you buy

EMSCO

PUMPING UNITS

"Engineered"—not just "built"

Designed and engineered to stand up under hard usage with minimum upkeep.

One of few unit lines available with anti-friction bearings throughout.

Precision-cut gears (not lapped) permit partial replacement in the field when necessary. High hardness gear material stands up under hard wear.

Quick, safe adjustment of counterbalances at ground level by one man. Emsco counterbalances may be adjusted to lead or lag the load as required.

Complete accessories, ground-level lubrication, guards, skid extensions, slide rails and modern brake.

Extra rigid gear case allows precision gears to operate as designed.

No oil seals to wear out in reducer.

Four-legged Samson post is extremely rigid.

Two sumps for oil to drop out emulsions or particles.

There's an Emsco Pumping Unit for every type of well. Send for two colorful new bulletins or see your nearest Continental or D+B store for complete information.

CONTINENTAL
Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY
A Division of The Youngstown Sheet and Tube Company
General Offices: Dallas, Texas
Representatives in all principal oil fields of the world

QUALITY EMSCO PRODUCT

D+B DIVISION
EMSCO MANUFACTURING COMPANY
Garland, Tex. • LOS ANGELES, CALIF. • Houston, Tex.
General Sales Offices: Dallas, Texas

PT-606

also be the case in induced water floods. The ratio of the vertical to horizontal permeability may be such that water coning results at certain flow rates.

Solutions: Waters that are foreign to the producing reservoirs may be shut off by preventing their vertical migration outside the casing in the bore hole. The most common technique to shut off such waters is to cement squeeze the completion interval. The squeezed cement follows the path of least resistance and may, in effect, result in a repair job to the primary cementing of the well casing. After sufficient setting time the cement is drilled out, the squeeze interval pressure and/or dry tested, and the well recompleted. Plastics and cement-oil mixtures have also been used to seal off and prevent the influx of such waters.

A study of the producing reservoir; i.e., the performance of other wells completed therein, the drive mechanism, the structure, and geology, are necessary to determine the source of the produced water. If there is a change in the fluid level in artificial lift wells where the fluid is known, invasion of water from a source other than the producing reservoir will be suspected. A comparison of the chloride content of the produced water in question with that of the known producing formation will indicate if the questionable water is native to the producing formation or not.

When the water being produced is native to the producing formation and it is desired that this water be shut off, the point of entry of the water should be known or assumed for effective planning of the required remedial work. Gamma Ray Surveys made in wells producing salt water have in some cases shown a reversal of this curve opposite that part of the completion interval permitting the entry of the salt water. The reversal of the Gamma Ray curve is thought to be due to radioactive salt deposited in the formation and on the well casing by the incoming salt water. In some areas the Neutron curve has indicated water-oil contacts.

Some wells have more than one producing interval open to the well bore. These intervals may or may not be producing from a common reservoir. If sufficient geological, reservoir, and production data are available, it may be possible to identify the interval that is permitting the water to enter the well bore. If this is not possible, each interval may be selectively produced and tested, provided there is sufficient space between the completion intervals to allow for packer seats. Such testing may be inclusive, though because each interval may not be definitely isolated. Also, fluids from one interval may have invaded other intervals and caused the test results to be meaningless, unless large volumes of fluid are produced. An electric log may be run to locate the water zone in wells producing from open hole sections or from open hole screen settings if the screen can be pulled and recovered (provided the formations of interest are far enough removed from the casing seat that the casing does not affect the logging device).

When it is known or assumed that the water is entering the well bore at the bottom of the completion interval, water shut-offs may be attained by several methods. Plastic plug-backs have been very successful in some areas, particularly the East Texas field. Bridge plugs with and without short protective cement caps have been used to shut off bottom water. Cement plugs placed either through tubing (or drill pipe) or by a dump bailer, have also been used for this purpose. Squeezing cement or cement-oil mixtures through the completion interval, drilling out to a point above the oil-water contact, and recompleting the well, may also be used to effect a water shut-off. The particular technique to be used is dependent on several factors, i.e., the reservoir rock, well depth, etc., but especially economics.

Remedial operations to reduce or prevent the influx of bottom waters in wells that produce from formations whose vertical permeabiluity approximates the horizontal permeability may not be successful because of water coning at even, low flow rates. The horizontal permeability might be increased by pressure parting or fracturing, and this would make remedial operations to shut off bottom water more successful. Most successful water shut-offs are obtained in reservoirs whose formations contain barriers to the vertical movement of fluids.

If it is known or there is reason to believe that the produced water is other than bottom water, and one or more producing section is open to the well bore, the water may be shut off by squeezing with cement or a cement-oil mixture. After it is drilled out, the squeeze interval should be pressure and/or dry tested to determine the effectiveness of the squeeze job. Reperforating of the oil section may not be necessary, if the cement-oil mixture was used, because the cement will not set if not exposed to water. This may also be found to be the case with the cement squeeze. However, if the cement squeezed oil section does not require reperforating, it is doubtful if a "good" cement job has been obtained, and the water shut-off will probably not be satisfactory or will fail in a short time.

Liners may be set in open holes and plastic, cement, or cement-oil mixtures displaced and allowed to set around the outside of the liner. This will seal off those formations penetrated by the liner and prevent the movement of fluids from one formation to another. A selective recompletion is made by perforating the liner.

PROBLEM: Plugging of the Producing Formation

Causes: **The natural permeability of the reservoir rock may be impaired by drilling or workover fluids; by the migration of formation fines to the well bore and their accumulation at this po!nt; by deposition of precipitates; and by an accumulation of paraffin.** No doubt there are other reasons for formation plugging, but the ones mentioned above will suffice to indicate some of the corrective measures that may be taken.

A drill or workover mud on the producing formation may cause an obstruction to fluid flow into the well bore, because of the properties that a *good* mud must have is the ability to build a highly impermeable sheath on the walls of the hole. The suspended solids increase the density of the mud to the point that it will exert sufficient hydrostatic head to balance pressures encountered in those formations penetrated. These properties are desired and necessary during drilling and some remedial operations. However, when the well is completed, it may be found that the use of a fluid with these properties has caused the flow of fluids from the formation to be blocked.

One of the requirements of a drill mud is that it permit the well to be drilled as quickly and as economically as possible. If the damage to the producing formation caused by the mud can be corrected by stimulation techniques at reasonable cost, a mud that is best suited for "hole making" can be used. The combination of hole making mud and stimulation techniques may result in cheaper producing wells.

Formation fines may be eroded from the reservoir rock by the fluids being produced, screened out, and accumulated in and near the inlet to the well bore in quantities sufficient to cause blocking.

The difference in well bore and formation temperatures and pressures may create precipitates such as gypsum which could

THE CALIFORNIA COMPANY, LOUISIANA GULF COAST

DESIGNS, ENGINEEERS and BUILDS COMPLETE PACKAGED GAS COMPRESSOR PLANTS

Southwest erects complete gas compressor plants: engineering, compressors, building, on one purchase order and with single responsibility from beginning to end. Southwest does the complete job in building compressor stations afloat, on platforms, or on land giving you faster delivery, lower *installed* cost, and undivided responsibility.

The unattended operation, possible with the automatic controls and safety devices on Southwest Packaged Compressor Plants, cuts operating cost per horsepower-hour to a fraction of the cost of a fully attended stationary installation. A Southwest engineer can show you actual comparative operating costs.

FOR GAS LIFT, GAS BOOSTER, PRESSURE MAINTENANCE AND SIMILAR PROJECTS

SOUTHWEST INDUSTRIES, INC.

Post Office Box 7773, Houston 7, Texas

The Author

Cliff J. Rodgers is a well remedial engineer on the division petroleum engineering staff of Gulf Oil Corporation's Houston division office. Born near Sour Lake, Texas, he was graduated from Louisiana State University in 1940 with a degree in petroleum engineering, and shortly after started to work for Gulf as a roustabout in the Thompsons field, Texas. He joined the U. S. Army in 1941 and served with the Corps of Engineers on the Alaskan Highway, briefly on the Canal Project at Norman Wells, Northwest Territory, in England and in Europe. He was discharged as a captain and rejoined Gulf. In 1949 he was made district engineer assigned to well remedial operations.

be deposited in the producing interval.

In some wells, usually at shallow depth, paraffin has accumulated and effectively plugged the producing interval.

Solutions: Formation blocking caused by drill or workover muds may be remedied by chemical or mechanical means. The most common mechanical device used is the wireline perforations washer and bailer. Others are: running perforation washers on tubing; swabbing; reverse circulating behind the casing and pumping harmless fluids into the formation. Acids are effective in removing precipitates, and formation fines. Paraffin may be removed from the well bore with solvents and heat.

WIRE LINE BAILER

Formation blocking caused by drill or workover muds may be remedied by chemical or mechanical means. The most common of the mechanical devices used is the wireline perforation washer and bailer. This tool is particularly applicable to those formations in which normal circulation pressure may cause returns to be lost. Salt water or a liquid that does no serious damage to the reservoir rock and reservoir fluids should be used as the drill fluid. The perforations are washed and bailed until the material recovered from the formation is free of mud. Mud acid, spotted opposite the interval being washed and bailed, has been used with some success to aid in the removal of the mud.

PERFORATION WASHERS RUN ON TUBING

Perforation washers run in on and actuated by the tubing string have been used in wells producing from competent formations and in wells completed below the effective working depth of wire line tools. Perforation washers run in on tubing may be so set that either fluid pressure or a suction will be exerted on the formation. It may be necessary to exert fluid pressure on the formation in order to loosen the blocking material. However, after loosening of the mud block, it is advisable that the action of the perforation washer be reversed (suction) in order to pull this material into the well bore to be removed. It should not be allowed to accumulate again and cause further blocking.

SWABBING

Another way to remove drill mud from the formation is to swab. This causes the well bore to sand up. When this occurs the tubing is lowered and the fill-in reverse circulated cut. A salt water or other compatible fluid is used as the drill fluid. After reversing out, the tubing is reseated and the cycle repeated until the returns appear to be free of mud.

REVERSE CIRCULATION BEHIND CASING

Reverse circulating a salt water or a harmless fluid behind the casing and opposite the formation (by setting a hookwall packer in the perforated interval) is often used. This method of removing drill mud is not as efficient as the technique previously described.

PUMPING IN THE FORMATION

"Pumping in" the formation either salt water, crude oil, distillate, etc., has also been used to penetrate or break down mud blocks in order to allow formation fluids to enter the well bore. There have been a small number of fracturing jobs performed in which the primary aim was to penetrate a mud block around the well bore. Some of the acidizing jobs of the past probably owe their success to the penetrating and breaking down of mud blocks rather than the effect of acid on the formation.

MUD ACID

Mud acid treatments, usually of the order of 1000 gallons or less, have proved very effective in removing mud blocks in wells capable of natural flow. In those wells where the reservoir pressure is greater than the hydrostatic head exerted by a column of salt water, this method of stimulation is probably the most effective. Underreaming the producing interval may also be used to remove mud sheaths. A drill fluid that is not harmful to the formation should be used for underreaming.

The techniques previously discussed for the removal of mud blocks would also be applicable for the removal of blocks caused by formation fines.

PRECIPITATE REMOVAL

The deposition of precipitates in the producing interval may be detected by the presence of such substances on the tubing or by an examination and analysis of materials recovered from the well bore by washing or bailing. Acid treatments are most effective in dissolving and removing this type of obstruction.

PARAFFIN REMOVAL

Paraffin may be removed from the well bore and the formation face by the injection of solvents. Hot oil or salt water treatments may be used, if the interval being treated is of relatively shallow depth. A new technique which is supposed to dissolve heavy residual oils and paraffin deposits is the injection of butane and oil mixtures of the order of 5000 to 20,000 gallons of mixture into producing section. The limited use of this technique indicates that further testing is required before its effectiveness can be completely evaluated.

PROBLEM: Reperforating and Recompleting

Causes: Reperforating may be desirable and in some cases mandatory in order to establish or maintain the flow of oil and gas into the well bore in commercial quantities. Sufficient or adequate penetration may not have been obtained in the original perforating attempt. The perforated interval in oil wells is often found to be incorrectly positioned. This is due not only to inherent human errors but also to the inaccuracy of techniques and measuring devices used in the past. The original perforations in old wells are sometimes found to be plugged or were never made because of the failure of the perforating guns to penetrate the casing. It is sometimes necessary to add perforations to the completion interval; i.e. expose additional section to the well bore so that more complete drainage of the reservoir may be obtained. It may be desirable to increase the density of perforations in the completion interval in order to promote more rapid and complete drainage. Perforations having larger hole diameter than the original ones are sometimes made in order to facilitate

With a Totco Recorder you have simplicity of operation, sustained *accuracy* in recording, and durability. What's more, these famous instruments are constantly being modified and improved. You can depend on your Totco even in the deepest, hottest wells.
Be sure you know, use Totco!

Accurate as a timepiece

TOTCO

Technical Oil Tool Corporation • *1057 North La Brea Avenue, Los Angeles 38, California*

Exclusive Distributors: *California*—The Republic Supply Co. of California; *Domestic*—The Continental Supply Company; *Canada*—Oil Well Supply Company; *Export*—Lucey Export Corp., New York City

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

the placement of materials such as gravel outside the casing. This may also be done to expose more of the producing formation to the well bore both in producing and injection wells.

Old wells producing from competent formations have profitably been reperforated in some cases with the newer, improved perforating guns that obtain greater penetration than those previously used.

When, because of a natural decline in production or for other reasons, it becomes uneconomical to continue to produce a particular zone in a well and other productive formations are penetrated by the cased hole, a recompletion may be made. A well may be recompleted in another productive zone in order to expedite or obtain more efficient recovery from all reservoirs within a field. Recompletions are also made in order to prevent drainage by offset wells.

Solutions: Through-tubing completion techniques are particularly adaptable to reperforating and recompletion operations. These techniques have been ably described.[1,2] Equipment has been perfected that permits logging and perforating operations to be performed in high pressure wells. Stranded wire line stuffing box units designed for 10,000 psi working pressure have been operated against 6000 psi wellhead pressures.

Most reperforating or recompletion operations require that a fluid be in the well bore when the casing is perforated in order to contain and control the formation pressures encountered. The fluid should be such that it will cause no permanent damage to the well completion. For this reason salt water, oil, or one of the prepared perforating fluids is frequently used. However, these fluids are comparatively lightweight, and the hydrostatic head provided may not be sufficient for the conventional wireline perforating of high pressure formations.

Instead of using a high weight drill mud as a perforating fluid for known high pressure zones or for zones whose pressure is not definitely known and possibly damaging the completion, the well may be equipped so that it can be completed by through-tubing completion techniques. The desired lightweight fluid may be used, the casing perforated by a through-tubing gun, and the formation pressure controlled and contained.

Another technique for perforating zones of high or unknown pressures with a lightweight fluid in the bore hole is the use of a perforating gun fitted to, run in on, and actuated by the tubing string or a go-devil dropped down the tubing. This tubing setting will permit testing and, if desired, continued producing of the well if it is capable of natural flow.

When a recompletion is to be made in a higher formation, it is necessary to plug the interval in which the prior completion was made. This is done to prevent the movement of fluids from either completion to the other. If the proper primary cementing techniques were used and it is known or strongly believed that the cement around the outside of the casing prevents the channeling or migration of fluids, plugging the inside of the casing above the completion to be abandoned is all that is required. Various types of plugs have been used. The selection of the particular type is dictated primarily by economics. Cement plugs placed either by a dump bailer or through tubing may be used. Plastic plugs made entirely of plastic or a sand fill capped by plastic and placed with a dump bailer may also be used. Bridge plugs may be used for this purpose and may be set by tubing (or drill pipe) though usually by a wireline. The top of the bridge plug may be protected by a cement cap which would also prevent the bridge plug's becoming dislodged.

If there is some question as to the effectiveness of the primary cement job and the recompletion is to be made in a higher formation, the interval being abandoned should be cement squeezed. A retainer should be used for squeezing in order to eliminate the possibility of having to drill out a part of the cement inside the casing. It may be necessary to block squeeze the interval selected for recompletion in order to isolate the fluids contained in this zone. The testing of the block squeeze and the recompletion are accomplished as outlined previously.

Isolation squeezing has been performed by perforating the interval in which the completion is to be made, squeezing these perforations, drilling out, testing the squeeze job, and reperforating for completion. This method is not widely used now because of the possibility of damaging the casing by the repeated perforating.

When the recompletion is to be made at a depth lower than the completion interval being abandoned, it is necessary that the latter be sealed off for reasons previously stated. This is usually done by cement squeezing. A retrievable squeeze tool should be used for placing the cement. After the cement is set, it is drilled out of the casing and the squeezed interval is pressure and/or dry tested. If the test is satisfactory and it is not necessary to block squeeze the recompletion interval, the casing may be perforated for the recompletion according to the applicable technique. If a block squeeze is required, it and the recompletion could be performed according to the procedures previously outlined.

References

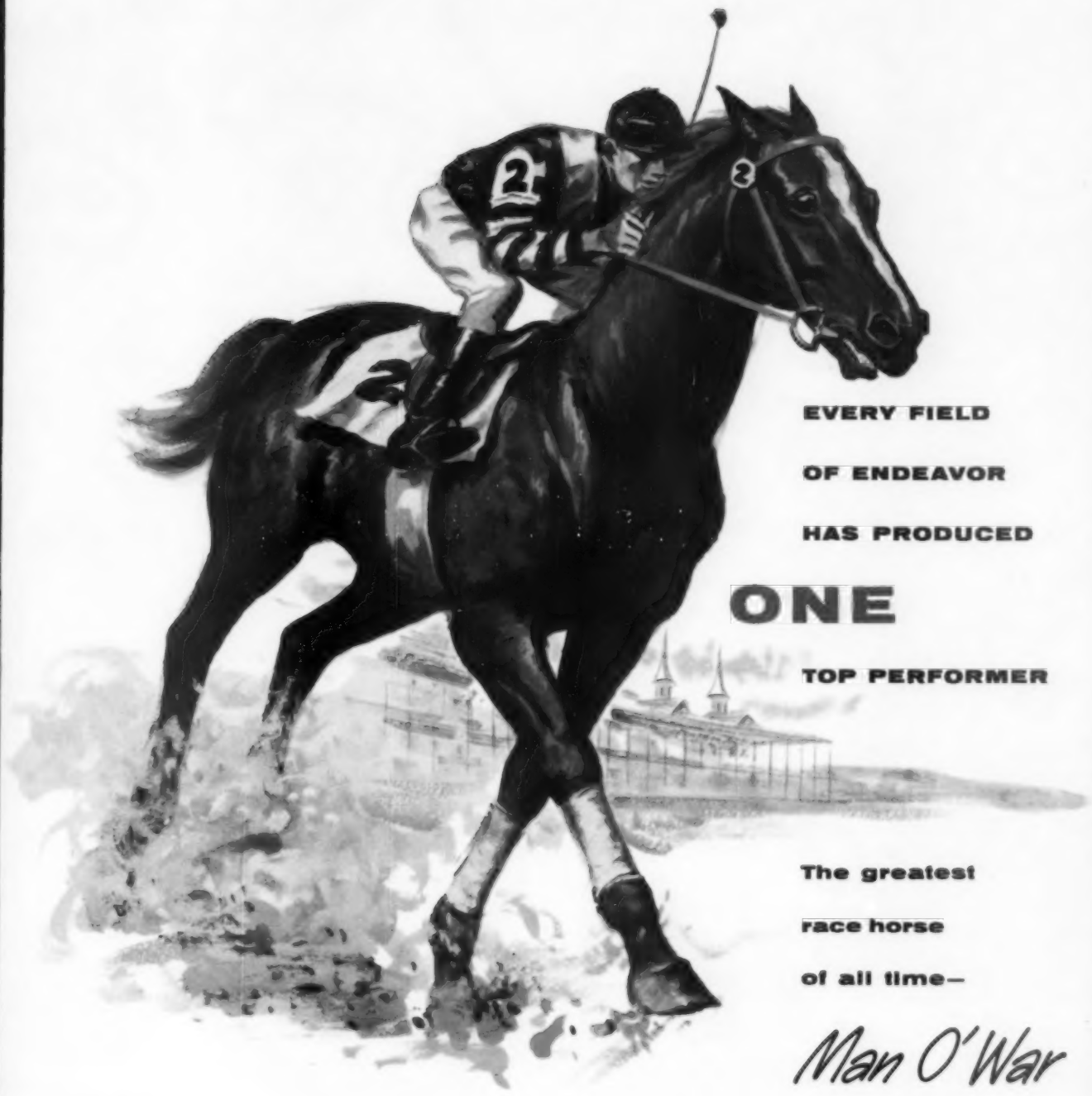
1. Huber, T. A. and G. H. Tausch "Permanent Type Well Completions," *Petroleum Transactions*, AIME, Vol. 198, 1953.
2. Courtney, Fred G. "Permanent Completions Pay Off for Gulf in South Louisiana," *The Petroleum Engineer* (Dec. 1955), B-46 to B-52.

PROBLEM: Producing Wells to Injection Wells

Special Considerations: Injection wells are used in pressure maintenance or secondary recovery operations and some salt water disposal wells are often classified according to type as injection wells. Producing wells may be converted and used as injection wells because of their structural positions and for reasons of economy.

If the fluid injection is to be into the same formation from which the well has been producing, it may be necessary for satisfactory injection to perform additional work other than reversing the direction of flow. Well equipment that was satisfactory for production may not be appropriate for injection purposes and will have to be replaced with equipment designed for that purpose. For example, if large volumes are to be injected, the tubing may have to be removed from the well or large tubing installed. If injection is to be down tubing and pressure is required to force the fluid into the formation, a hold-down type or tension-set type packer should be installed on the lower part of the tubing. If the injected fluid is more corrosive than that formerly produced, or if a larger volume causes a more corrosive condition to exist, it may be necessary to replace the well equipment with other equipment more resistant to corrosion. Too, equipment for chemical treatment to retard corrosion might be required in the well. Surface treating and conditioning of the fluid to be injected may be needed to prevent or retard plugging of the formation.

If the injection is to be into a formation other than the one from which the well has been producing, it will be necessary for the producing interval to be sealed off and a recompletion made in the injection zone. This may be accomplished by plugging or squeezing the producing interval and perforating the interval selected for injection. A block squeeze should be performed before the injection completion is made, if the



EVERY FIELD

OF ENDEAVOR

HAS PRODUCED

ONE

TOP PERFORMER

The greatest

race horse

of all time—

Man O' War

EVERY FIELD OF ENDEAVOR

HAS PRODUCED ONE TOP PERFORMER

In horse-racing it was Man O' War.

For smooth, free plunger operation under all kinds of pumping conditions it is

oilmaster

HARDENED AND HONED ONE PIECE PUMP BARRELS

Their design and general construction can, has and will be copied, but THIRTY YEARS OF EXPERIENCE and KNOW-HOW in this field of endeavor are the exclusive property of FLUID PACKED PUMP COMPANY.

FLUID PACKED PUMP COMPANY
Main Office and Plant
Los Nietos, California

Distributed by The National Supply Co., Pittsburgh, Pennsylvania • Export: The National Supply Co., Export Division, 600 Fifth Ave., New York • Co-Distributors: Union Supply Company, Beacon Supply Co., Industrial Supply Co.

FREE REPRINT AVAILABLE
Reprints of the illustration of Man O' War without advertising sent on request

quality of the primary cement job opposite the injection zone is questionable.

Injection rates are usually much larger than producing rates. For example, at water flood injection or salt water disposal wells, it may be necessary to inject thousands of barrels of water daily; whereas, the daily volumes withdrawn from producing wells are considerably less. In order to inject large volumes at reasonable and economical pressures, sufficient reservoir rock must be exposed to the well bore, possibly more than is necessary in producing operations. This may be accomplished by perforating or by the complete removal of the section of casing opposite the injection zone. If injection is to be through perforations, the length of the perforated interval, the density of the perforations, and the hole size of the perforations should be such that the reservoir rock is amply exposed to receive the injected fluid effectively and efficiently.

The casing opposite the zone of injection may be removed by "milling out" to provide complete and maximum exposure of the reservoir rock. In incompetent formations, however, it is necessary that some form of retaining wall, such as a gravel pack held in place by a strainer, be installed to prevent sloughing into the well bore.

In addition to providing for the exposure of sufficient reservoir rock, it is necessary that any block to the natural permeability of this rock is removed. In some cases it may be necessary to increase the natural permeability. The flow of fluid from producing wells tends to cleanse the formation face as the well is produced. In injection wells, however, foreign substances or materials on the face of the formation will be held in place and restrict the rate of injection.

Various methods and techniques have been used to cleanse the walls of the exposed bore hole and thereby remove blocks to the natural permeability of the reservoir rock. Injection wells incapable of natural flow are often jetted with gas to cause them to produce at high rates so that fluids entering the well bore will remove the blocking material and carry it in suspension to the surface. When the injection zone is in open hole or the casing opposite this zone has been milled out, it is possible to underream and enlarge the bore hole. A drill fluid that is not harmful to the formation is used for this operation. In addition to cleansing the formation face, some increase in injection capacity will result from the larger bore hole. The techniques used in producing wells to remove permeability blocks; i.e., bailing, perforation washing, etc., are applicable also to injection wells. Acids are commonly used for this purpose. The acid may be placed opposite the zone of injection and allowed to react with the material on the formation face and also the formation itself. Acid may also be injected into the formation. In order to prevent all the acid from being injected into only the most permeable part of the zone being treated, a selective acidizing tool may be used. Such a tool permits short intervals of the zone being treated to be isolated and acid injected into them. The entire injection zone may be so acidized by repeated settings of the tool.

Acids may not only remove blocks to the natural permeability but may increase this permeability by their action on the reservoir rock. Some increase in permeability no doubt results from pressure parting as the acid is injected. The natural permeability may be increased by fracturing; however, the effect that induced fractures will have in a reservoir being water flooded or in which pressure maintenance operations are in progress should be known before the fracturing operations are begun. Fracturing has been beneficial in salt water disposal wells as a means of increasing the permeability and thereby the rate of injection.

Acknowledgment

The author wishes to express his appreciation to the Gulf Oil Corporation for permission to publish this article.

QD means Quick Delivery

"Here comes your QD Sheave — the original two-piece design."

It also means Quick Detachable—name for the most popular sheave in the oil fields.

These two meanings belong together because quick delivery is what you get when you order Worthington Quick Detachable sheaves or Worthington-Goodyear V-belts from your local Worthington distributor (or oil field supply store).

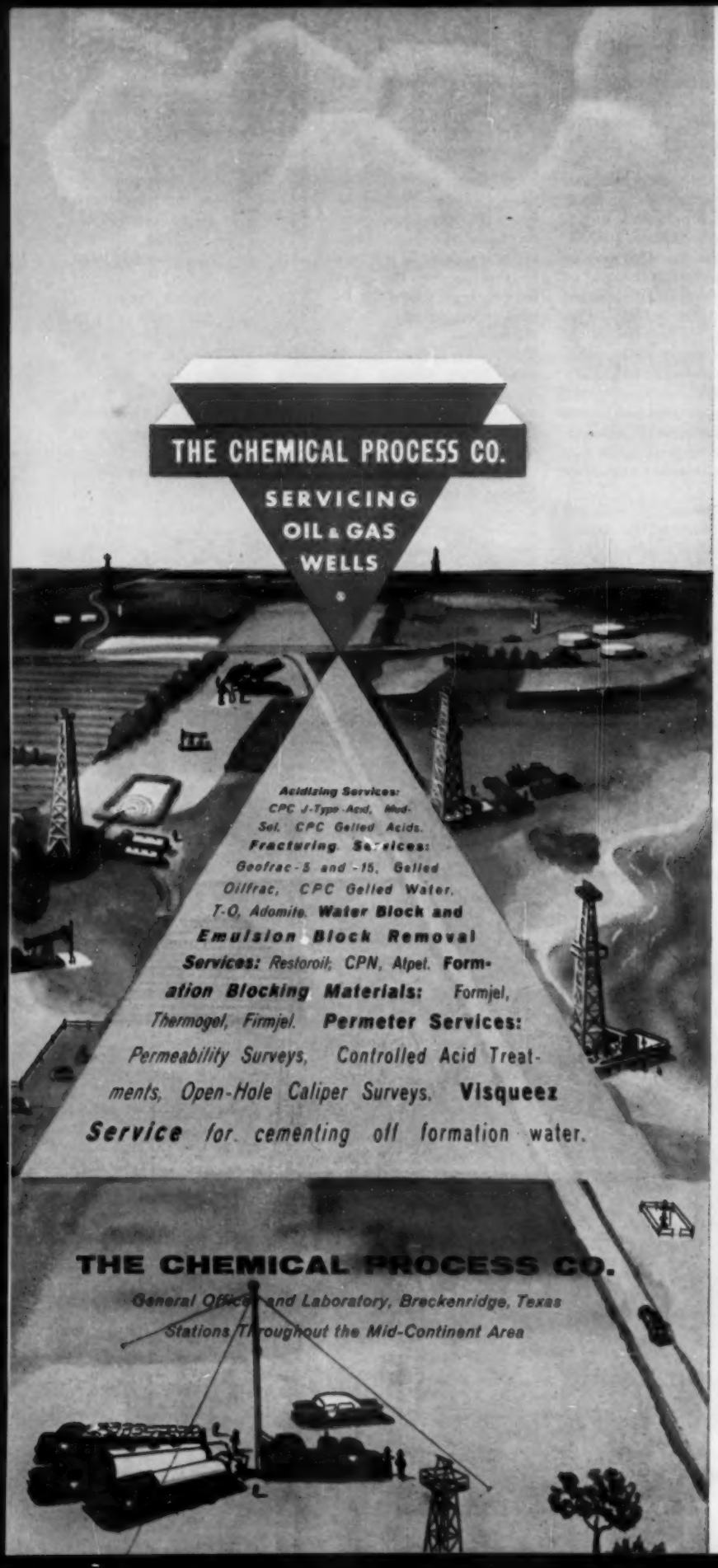
It's a point worth remembering next time you need one of the original two-piece sheaves. They're easy to get on, easy to get off, but hold tight on the shaft. Call your local supply store now for the size QD sheaves and V-belts you need.

MV.6.2

WORTHINGTON

Buy These Worthington Standard Products From Your Local Distributor

COMPRESSORS • MULTI-V-DRIVES
VARIABLE SPEED DRIVES • PUMPS


THE CHEMICAL PROCESS CO.
SERVICING
OIL & GAS
WELLS
Acidizing Services: CPC J-Type Acid, Mud-Sol, CPC Gelled Acids. Fracturing Services: Geofrac-5 and -15, Gelled Oilfrac, CPC Gelled Water, T-O, Adomite. Water Block and Emulsion Block Removal Services: Restoroil, CPN, Alpet. Formation Blocking Materials: Formjel, Thermogel, Firmjel. Permeter Services: Permeability Surveys, Controlled Acid Treatments, Open-Hole Caliper Surveys. Visqueez Service for cementing off formation water.
THE CHEMICAL PROCESS CO.
General Offices and Laboratory, Breckenridge, Texas
Stations Throughout the Mid-Continent Area

Morris & Hamilton Launch Mobile Offshore Rig

The "Carter Mart," named for a 5-year-old boy, is the newest addition to the Morris & Hamilton Drilling Company offshore fleet. Houston builders have recently completed construction of the offshore mobile drilling platform to be used in offshore drilling operations in the Gulf of Mexico.

This platform incorporates a drilling rig, the components of which are said to include the largest drawworks ever built and is driven by 2400 available diesel horsepower supplied to the drawworks and pumps. The rotary and mud mixing pumps are independently driven, making a total of over 3600 available diesel horsepower driving the entire rig. The cantilever type mast, traveling block, swivel and hook have a capacity of 500 tons being rigged with 1⅜-in. drilling line. This capacity is capable of drilling to depths in the range of 20,000 to 25,000 ft. Reserve and active mud pits have a capacity of 1210 bbl.

The platform was designed by Christenson & Graham, Inc., Pasadena, Texas, with construction being carried out by Sprague Welding & Machine Works at its Greens Bayou yard.

The basic hull of the vessel is 230 ft long, 99 ft wide at one end, 75 ft wide at the slot end, and 11 ft 9-in. deep, with a 22 by 70 ft drilling slot.

Centrally located in the basic hull is a pump room adequately ventilated with a 6000 cfm blower. The pump room is accessible from the upper structure through a four foot diameter, water tight, access tube. This pump room contains the two, 1500 gal per min ballast pumps, fresh water transfer pump, stand-by cooling water and fire pump, two fuel oil transfer pump and one sump pump.

The Texas deck consists of two levels, the lower of which is 65 ft above the bottom of the basic hull with 10 ft between the two levels, making a total height of 75 ft overall for the height of the structure. The Texas deck is supported by fixed columns suitably braced to withstand the forces of wind and wave. The complement of machinery installed on the Texas Deck has been carefully planned to carry on the operations of drilling in the most economical manner.

Crew quarter accommodations are provided on the second level of the Texas Deck for 56 men. These quarters are completely air conditioned with adequate sleeping quarters, showers and toilet rooms, scullery, gallery, mess hall, lounge and a game room. A helicopter deck is provided on the roof of the quarters.

When Working Over a Well . . .

SPECIAL Well Workover FEATURE

Unusual Methods Pay Off--SOMETIMES

Both oil man and engineer, the author gives a few cases to illustrate his point.

T. J. McIntyre, *president, McIntyre Oil Company, Houston, Texas*

TECHNICAL developments have been coming fast in the oil field. New techniques, new devices and new chemicals are announced almost every month. Many of them no doubt will prove valuable tools for the oil operator. But none of them will take the place of *thinking, planning and improvising.*

An ailing well is a pain in the neck and as common in the oil industry as a bad cold. It hurts most in the pocketbook, and perhaps this is why the oil industry — consciously or unconsciously — seems to hope and dream of a "cure all" (similar to miracle drugs) for ailing wells.

Evidence of this is the many *fads* that have swept through the industry from time to time. Take gravel packing for instance. Today, it is one of the most valuable techniques we have for controlling sand; but several years back, when it was first introduced, a number of operators set out to gravel pack every well that made a grain of sand. Many wells were damaged, some were ruined by the technique when it was misapplied. The trouble was *not* with gravel packing but with the lack of understanding of its purpose and limitations.

This is not to say that engineers and operators should not try new things. Just the opposite. The point is that before any technique new or old is used, those who apply it should carefully ascertain its purpose and then determine whether or not it can be successfully applied to the particular well in question.

Meanwhile, we sometimes fail to use the techniques at hand to the fullest advantage. Remember the old story about the farmer who was approached by a book salesman who wanted to sell him a book on modern farming. "What do I need a book for?" the farmer asked, "I'm not farming half as good as I know how, right now."

The same thing is true of the oil industry. We're not making full use of the tools now at our disposal. **Too many engineers come up with pat answers for any given problem. More thinking and planning would mean a higher success ratio for our workover jobs today. Engineers and operators should regard each well as an individual case — requiring special attention.**

Sometimes the ability to improvise — using old techniques in a new manner pays off like three bars on a slot machine. Here are examples that proved highly successful (but keep in mind, these remedies worked on specific wells — they will not work on *all* wells):

Unorthodox Techniques

A thin zone problem. Perforating in the shale above a sand that had an oil-water contact just three feet below the top of the sand saved a well.

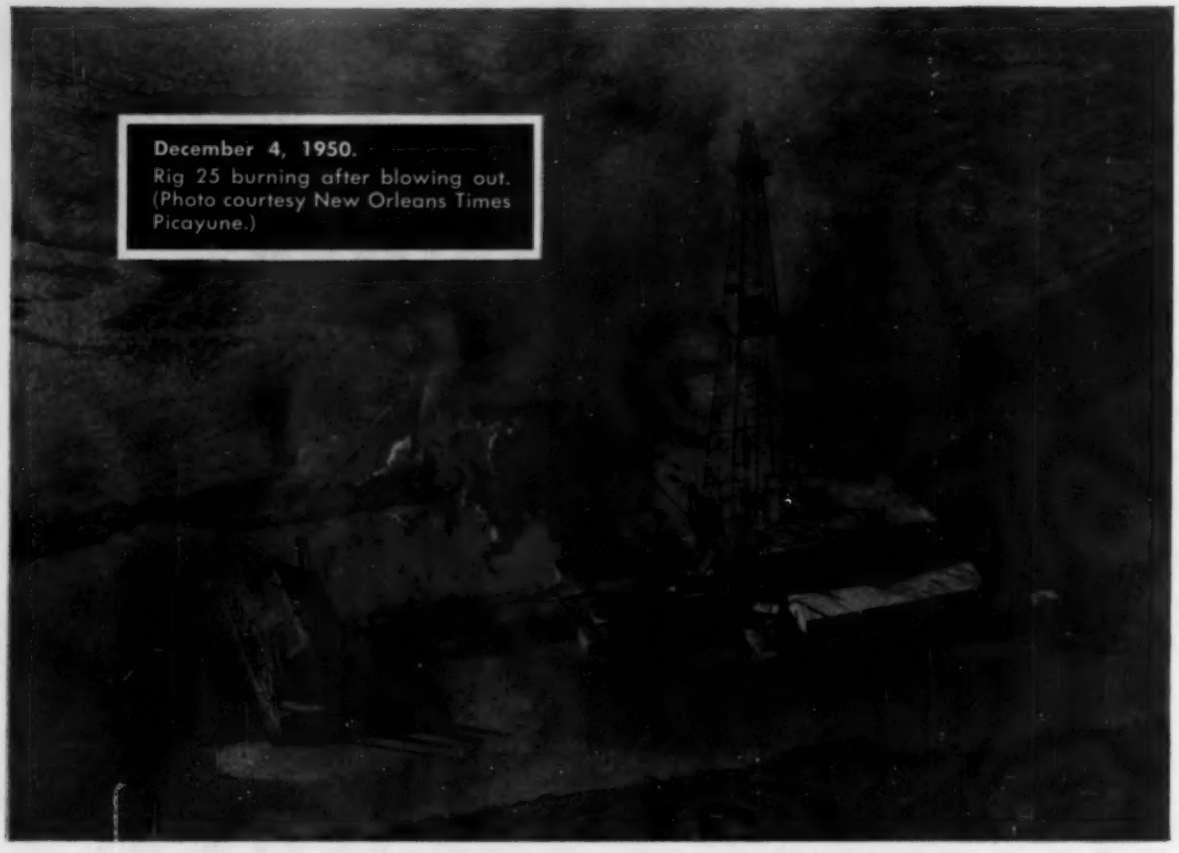
In Louisiana, an attempt was made to complete a well in a Miocene sand at approximately 7000 ft. The sand was approximately 20 ft thick; it was unconsolidated and the oil-water contact was 3 ft from the top. On the initial completion, the well was perforated in the top 2 ft of the sand. It flowed a

The Author

T. J. McIntyre is both an oil operator and an engineer. He drilled his own first well in 1949 and since that time he has developed a considerable number of oil properties in South Louisiana. He discovered and named three oil sands in the area: First, the McIntyre sand named after himself; second, the Eisenhower sand, named after his favorite President of the U. S.; third, the Eisenhower 2 T sand, named for the "Second Term," of course.

From 1947 until he entered the oil business on his own, he was a petroleum engineering consultant. From 1943 to 1947 he was district engineer for Sun Oil Company in South Louisiana and prior to that he had been with Shell Oil Company. He attended Murray Junior College two years and Texas A&M in 1938-39.

One of the unusual feats he performed outside the oil industry was to return The Ordinance of Secession to the State of Louisiana. This historic document was captured when Baton Rouge fell in the War Between the States and was carried to Wisconsin and later to California. McIntyre heard of this and through friends was able to get the document returned to former Governor Robert Kennon of Louisiana.



December 4, 1950.
Rig 25 burning after blowing out. (Photo courtesy New Orleans Times Picayune.)

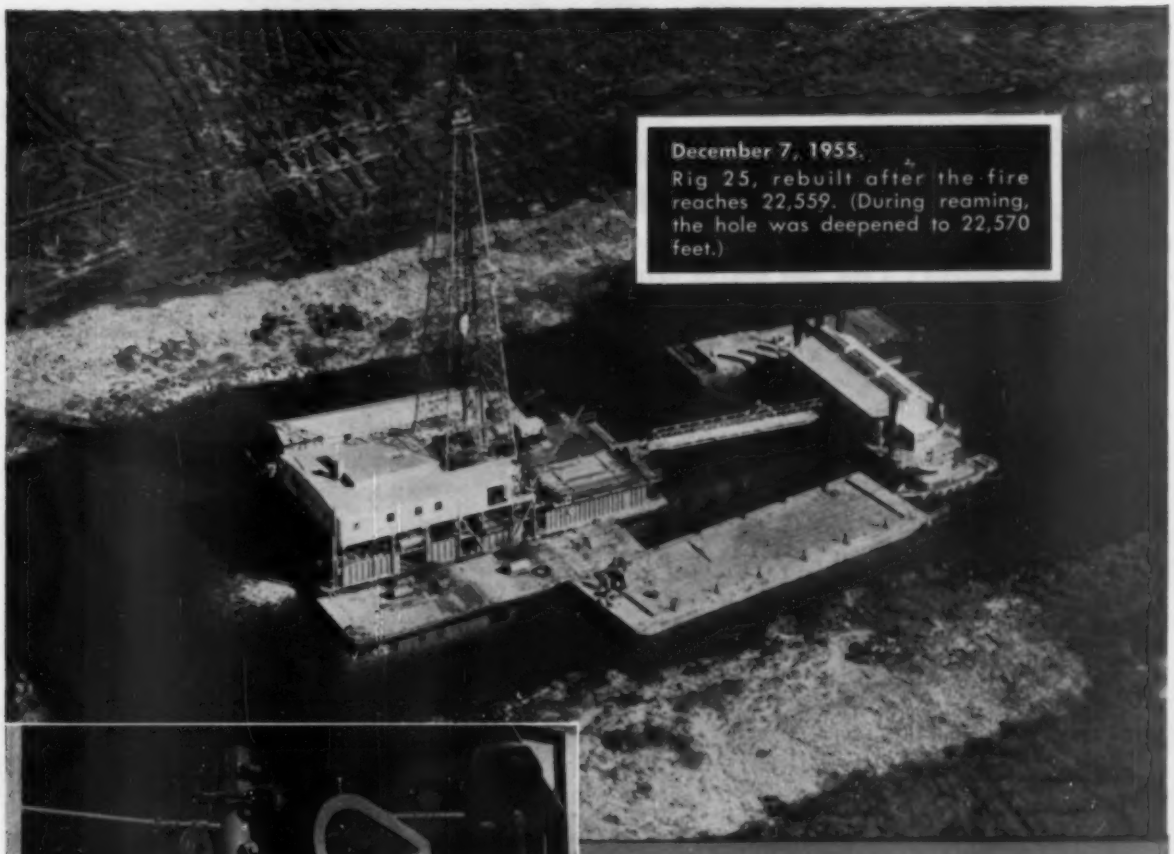
how this well fire paved the way for drilling the deepest well in the world

On December 4, 1950, Richardson & Bass' Rig 25 was drilling at 11,682 feet in the marshes of South Louisiana when the well blew out. The rig caught fire and was very badly burned. This fire pointed out the desirability of an effective way to remove gas from drilling fluids, and the first experimental model of the SWACO D-Gasser was installed on rebuilt Rig 25 on May 17, 1951.

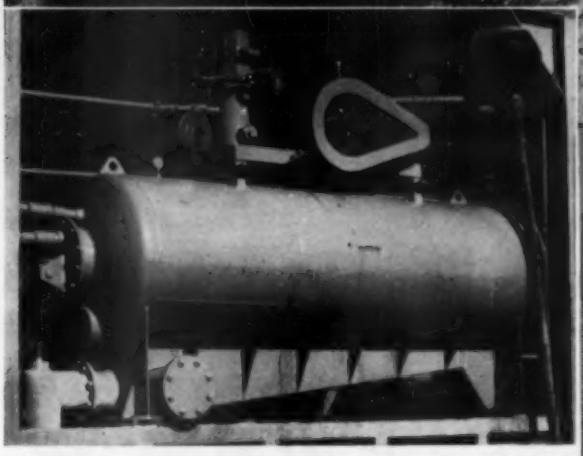
The D-Gasser marked the beginning of a new era in safety for operators in high pressure areas. Since 1951, Rig 25 has drilled many marshland wells without fire or blowout. While much credit for this performance must go to Richardson & Bass equipment, drilling personnel, and mud engineers, the D-Gasser certainly played a vital part.

SWACO D-Gassers are now standard equipment on all Richardson & Bass Gulf Coast rigs as well as many rigs of other Gulf Coast operators.

By removing all the gas from all the mud as it is circulated, SWACO D-Gassers have prevented many blowouts and fires. Some leading operators have said that D-Gassers have made possible the drilling of many wells that could not have been drilled otherwise.



December 7, 1955.
Rig 25, rebuilt after the fire reaches 22,559. (During reaming, the hole was deepened to 22,570 feet.)



This SWACO Mud D-Gasser is installed on Rig 25. It was inspired by the 1950 fire and was given much credit for helping keep the deep well under control.

HERE'S HOW THE SWACO D-GASSER HELPED IN DRILLING THE WORLD'S DEEPEST WELLS

- Saved hundreds of thousands of dollars in mud costs.
- Saved untold hours of rig time that would have been lost while building up mud weight.
- Permitted the reasonably safe use of over 16 lb. mud for over two months while drilling in treacherous open hole from 13,656′ to 19,752′.
- Made it possible to tolerate continuous gas-cutting from about 13,656′ to bottom. This allowed the use of drilling mud on the lighter side of the mud balance to avoid lost circulation and sure loss of hole.

THE DEEP HOLE

The SWACO D-Gasser played an important part in drilling the deepest well in the world which was recently made into the deepest producer. This well is an outstanding example of how the D-Gasser can save holes as well as time and money.

J. E. Hill, General Manager for Richardson & Bass, said the record would never have been attempted without the D-Gasser. Actual experience proved the soundness of this judgment.

At a number of points before reaching 19,572 feet, mud was gas-cut from 17.9 to 13 lbs. per gallon and lower. This could easily have been a major emergency without the D-Gasser because it would have been nearly impossible to control the mud within the

narrow range of weights required. In most instances, the difference between blowout and lost circulation was only three-tenths of a pound per gallon.

THE BIG TEST

The big test, however, came just as the hole was at 21,463 feet, when 18 lb. mud was severely gas-cut to 11.9 lbs. per gallon. The D-Gasser continuously restored the mud to its original gas-free weight.

Two considerations made it imperative to avoid weighting the mud any more than necessary.

First, it was difficult to maintain the lime base mud under the high temperatures being encountered. Adding weight material would have compounded the difficulty.

Second, it was essential to avoid any possibility of lost circulation because, at this depth, lost circulation would have meant almost certain loss of the hole.

With the D-Gasser, it was possible to tolerate gas-cutting continuously from the bottom of the 9⅝" protection string at 13,656 feet, to T. D. at 22,570 feet. This permitted holding the mud weight only slightly above the indicated bottom hole pressure encountered as drilling progressed. If the D-Gasser had not been available, this would not have been possible, and the chances of losing the hole due to lost circulation would have increased enormously.

HOW THE D-GASSER CUT COSTS

The total drilling mud bill was $630,-811.95. Since there was no control well for comparison it is impossible to tell just how much the D-Gasser saved in mud costs.

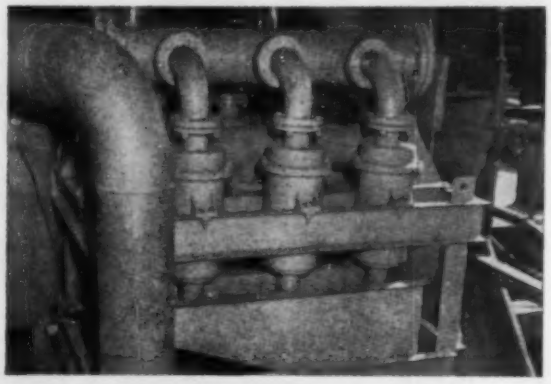
However, over 1,000 wells have been drilled using the D-Gasser and many reasonably accurate comparisons have been made.

Based on this experience, it can safely be said that the mud bill without the D-Gasser might have been more than one million dollars—*if the well could have been drilled at all.*

Based on the same experience, it is certain that the D-Gasser saved many hours of rig time.

Richardson & Bass has not lost a rig due to blowout or well fire since SWACO D-Gassers have been installed. Savings in mud costs and drilling time alone have been enough to pay the entire cost of the D-Gasser many times over.

SWACO D-Gassers are rapidly becoming accepted as standard equipment for Gulf Coast and offshore rigs, as well as rigs operating in other high pressure areas. If you are drilling in such an area and are not using the D-Gasser, write us. It is possible that it can save your money as well as protect your rig investment.



The DORRCO D-SANDER effectively removes sand and drilled solids from the drilling fluid. Extensive field experience has proved that it speeds drilling, reduces pump maintenence costs, and offers many other important benefits. A D-Sander is installed on Rig 25 to reduce the cost of drilling through the sands that predominate in South Louisiana above 9,000 feet. For full information on this outstanding piece of equipment, call or write us.

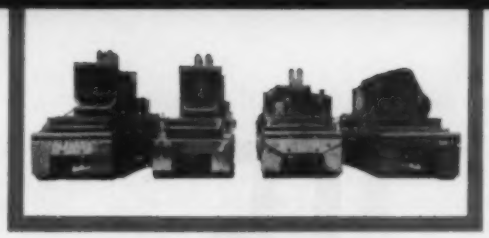
SWACO

SALT WATER CONTROL Inc.

A Sid Richardson Development Company

1211 Ft. Worth National Bank Phone: ED 2-4434 Ft. Worth, Texas

PICK IT UP—LOAD IT ON 4 TRUCKS AND TRANSPORT IT TO THE NEXT JOB

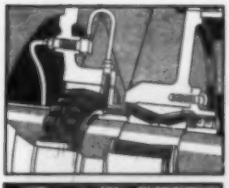


THE NEW

EMSCO A-800 RIG

(800-1100 H.P.)

A TRIUMPH OF PERFORMANCE, RELIABILITY, LUBRICATION AND EASE OF MAINTENANCE



PRESSURE LUBRICATED BEARINGS

Each bearing has its own supply of clean, filtered oil which flows through the bearing assembly flushing out all dirt and insuring maximum bearing life.

POSITIVE "SPRAY" LUBRICATES CHAINS

All chain drives are continuously lubricated by a positive oil spray system. Oil flows through the hubs of the sprockets and sprays into the path of and through the chains.

PORTABILITY

Maximum portability saves time and money. The rig ships easily on 4 trucks in 4 convenient packages of road dimensions, with a minimum of tear-down and rig-up time.

PERFORMANCE

Simple, practical design, heavy duty construction, greatly improved brake cooling system and new friction compounding clutch cut operating costs and maintenance and insure superior performance.

Get all the facts on the new Emsco A-800 Rig (800-1100 hp). Call Continental today.

CONTINENTAL

Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: Dallas, Texas

Representatives in all principal oil fields of the world

EMSCO

QUALITY IS OUR PRODUCT

EMSCO MANUFACTURING COMPANY

Garland, Tex. • LOS ANGELES, CALIF. • Houston, Tex.

General Sales Offices: Dallas, Texas

R-608

25 YEARS LEADERSHIP

IN PRODUCTION AND COMPLETION TOOLS

FOUR BROWN FIRSTS

BROWN DUO-PAK PACKER
All purpose packer for all producing problems.

BROWN SOS J-7 PACKER
Simplest, shortest, safest, retrievable, drillable.

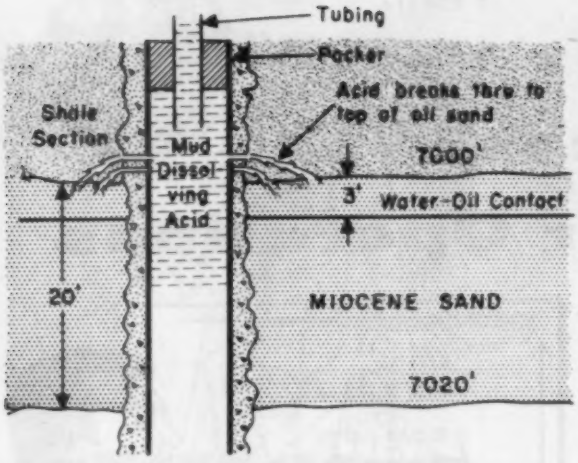
BROWN TYPE "A" ZONE SELECTOR
Eliminates outside service crews, zones comingling, killing well and pulling tubing, disturbing packer setting.

BROWN SOS DETACHABLE DUAL STRING PACKER
New, simple in design and operation, retrievable. Economical, sets automatically, needs no surface manipulation or tubing weight.

For further information write:

BROWN OIL TOOLS, INC.
2214 CAMPBELL ST.
HOUSTON, TEXAS

BROWN IS *FIRST* WITH THE BEST EQUIPMENT



Unorthodox completion by perforating in shale section above thin oil column, squeezing mud-dissolving acid to break through to top of oil sand.

small amount of oil and salt water for a short time and then sanded up.

Remedial work was then started. The initial step was to attempt to eliminate salt water infiltration. The operators mixed 150 sacks of slow set cement and broke the formation at 2500 psi. A final squeeze pressure of 3500 psi was reached with about 90 sacks out in the formation.

The cement was permitted to set 36 hours, drilled out and the well was re-perforated in the top foot of the sand. This recompletion attempt was a failure and once more the well sanded up after producing salt water, oil and sand.

The third attempt was a failure too. The operators tried to consolidate the sand with a consolidation plastic. About 500 gal of plastic was pumped into the well and after two hours, a build up of pressure failed to materialize when pumping with displacement oil. An additional 500 gal were staged into the formation, but once again the pressure build-up didn't come. The operators "assumed" that consolidation was complete, and once more attempted to flow the well. Once again it sanded up after producing a small amount of salt water and oil.

At this stage, a consulting engineer was called in to make a fourth attempt at completion. He decided to use a new approach. About 500 gal of mud dissolving acid was spotted ahead of the cement to wash the face of the sand and perforations. This was followed by 150 sacks of cement. The breakdown pressure was 2700 psi and the final pressure was 3700 psi with 120 sacks out in the formation.

After the usual waiting time, the plug was drilled, and a drillstem test was made with 3000 ft of water cushion. The test was dry.

This time the well was perforated one foot above the sand up in the shale. When the well failed to flow, 200 gal of mud-dissolving acid was spotted in the tubing and 100 gal of it was displaced through the perforations in an attempt to open up to the top of the sand. The pressure was released after two minutes, but the well failed to flow.

The balance of the acid was then displaced through the perforations and after two minutes (the time was limited to protect the cement job) the pressure was released and the well came in flowing. It had a flowing pressure of 800 psi and made approximately 110 bbl per day of pipe line oil through a 7/64-in. choke. It was placed in production through a 5/64-in. choke and produced at 80 bbl per day.

The well produced for eight months before making any salt water, but after two years it sanded up again; but nevertheless it enabled the operators to recover a substantial portion of their investment.

Perforating high pays off. Another well completed in a similar manner proved more successful. The well was completed in the Frio, and the sand was approximately 80 ft thick with the top at about 10,100 ft. By wire-line coring, the oil-water contact was found at 10,103 or three ft from the top of the sand. The well was perforated from 10,097 to 10,100 or in the shale three feet above the sand.

When the well was swabbed down about 3000 ft, it came in flowing and after 12 years it still makes 90 bbl of oil per day.

The primary advantage in perforating above unconsolidated sand sections is that the pressure of the overburden tends to hold the sand in compression and it will not flow upward as readily as horizontally or downward. The rigidity of unconsolidated sand in compression is sometimes well illustrated when a small amount of it gets behind a packer, requiring a wash over to recover the packer.

Another possible explanation for the success of this operation is that perhaps the pressure of the oil in the producing formation fractured the shale in reverse — that is, it opened up passage ways from the top of the producing formation into the perforations up in the shale.

Problems in squeezing. In my opinion, one of the most unfortunate practices in the oil industry has been the needless and often harmful block squeezes that have been applied during the initial completion of high-pressure sands where the oil-water contact and perhaps the gas-oil contact are in the borehole interval. Even today, many operators complete a zone of this kind by first perforating and block-squeezing at the water-oil contact, then perforating and squeezing at the gas-oil contact and then perforating for a production in the oil column.

It has been my experience that it is best to simply perforate the oil column and try for production before doing anything to further disturb the formation. And when cement squeezes are attempted under the conditions above they should be preceded by mud dissolving acid to clean the face of the sand. Even then, the best place to attempt the squeeze is through the production perforations.

Pea-gravel added to cement slurry makes successful squeeze. Here is an unusual case. The well was only 2300 ft deep and there was a definite break between an oil sand and a salt water sand. The initial cement job failed to control the salt water flow and the more water was produced, the more of the friable unconsolidated sand produced.

Two squeeze jobs were attempted, but both failed to stop the water and sand. Apparently the water cut a considerable channel along side the casing and cement slurry could not fill it up.

As a stop-gap measure, pea-gravel was added to the cement slurry downstream from the pump and a successful squeeze job was done.

Why did this work? There could have been several reasons. For one thing, the formation would not take great pressure and chances are the cement was not being dehydrated to sufficient density on previous squeeze jobs. The added density from the pea-gravel could possibly have made the difference.

But more likely, the pea-gravel screened out and bridged between the two zones. This aided in making a more impermeable barrier for the cement.

On the other hand, maybe the cement and pea-gravel invaded the oil sand, gravel packing it along the bedding planes thus effectively adding to the area of the oil producing zone.

It could have been a combination of these factors. But in any case, this procedure saved an oil well — which brings me to this: It's dark below the rotary table, and many things happen underground that none of us fully understand. When someone once described golf as a "humbling game" — he might well have included the oil game too. ★ ★ ★

SPECIAL
Well Workover
FEATURE

Safe Practices In Workover Operations

Don A. Klemme, *Safety Supervisor, Stanolind Oil and Gas Company, Tulsa, Oklahoma*

Safety should be as much a part of the planning as the job itself. One accident can more than offset the rewards anticipated from the workover.

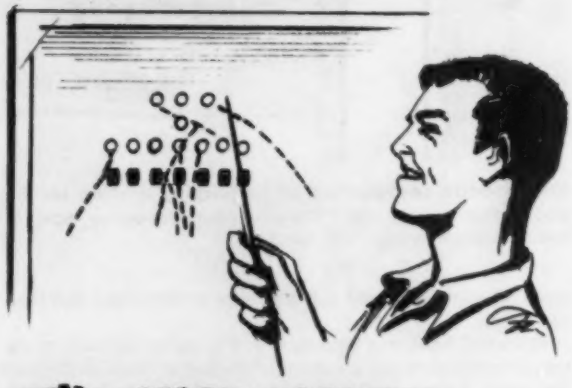
FOR maximum benefits to be acquired from a workover, the operation must have "job safety" planned into each step. One accident can more than offset the reward expected from the workover.

Should the accident result in severe injury, the loss would not only be great to the injured and his immediate family, but in addition the company would lose the services of an experienced man. Most accidents, whether an injury is involved or not, reflect in decreasing profits in a direct or indirect way.

In planning a workover, characteristics of the well determine what type of equipment will be used and what is to be done to make it more productive. This type of planning involves the "how." Of equal importance in the planning are the people who will do the work.

The workover job should not be started without a definite understanding with the workmen as to what is expected of them. Even more important, each workman must understand the job assigned to him. This is the responsibility of the supervisor in charge. It is he who must be positive that safe work methods are being employed and understood. A supervisor cannot take for granted any phase of the operation involving the safety of his men or equipment.

Equipment Considerations. In any workover job, the rigging up process varies according to the type of prime mover used, such as rotary tools, cable tools or portable unit. The necessary work in connection with rigging up, whatever type



THE COACH MAKES THE TEAM

of equipment is used, may involve the use of winches, gin poles, derrick lines, tractors, etc. This requires that extreme precautions be carried on at all times for the protection of the equipment as well as the worker.

Housekeeping is often forgotten during the rigging up operation. Too often, miscellaneous tools, pipe and equipment are allowed to accumulate in the work area, restricting the free movement of the worker and subjecting him to hazards of falling over equipment.

Some equipment appears too light to be handled by a winch line or a boom, and the workman attempts to manhandle it. This often leads to serious "dropping" injuries in the form of smashed hands or feet, or severe injury to the back from trying to lift too much.

Immediately after the essential pieces of equipment are in place — **before work starts** — equipment guards should be installed where they are needed. It is just as important to have the safeguard on a block or a drum as to have the prime mover ready to go.

Numerous hand tools are required around a workover job. These should be racked in a place provided and kept there when not in use. Naturally, this should be in a place out of the immediate work area.

Protective Equipment. Personal protective equipment needed for the workover job should be given due consideration. Such things as hard hats, safety shoes and eye protection are needed on most workover jobs. In some particular instances unusual hazards are presented, such as sour gas and chemicals that have been used in the treatment of the well. They should be guarded against by workers' wearing proper personal protection.

It is a good idea for all the crew to have a working knowledge of first aid and its application, especially the control of bleeding and artificial respiration. This is something that should not be taken for granted. It should be ascertained that the workmen are qualified to take care of a fellow employee in the event of an emergency. It is better to ascertain these

---

The Author

Don A. Klemme is safety supervisor for Stanolind Oil and Gas Company, with 26 years' experience in the field of safety. His career in the oil industry started when he went to work as a roustabout in the oilfields of Wyoming. Later he worked at a variety of jobs, including tool dresser, gang pusher and other oil producing occupations. He is chairman of the safety committee, Mid-Continent Oil and Gas Association and vice president for industrial safety, Oklahoma Safety Council. He has served as general chairman of the Petroleum Section of the National Safety Council; president of the Tulsa chapter of the American Society of Safety Engineers; chairman of the Tulsa Chamber of Commerce Fire Prevention Committee. In addition he holds memberships in many other safety organizations.

---

facts well in advance. Emergency first aid may be needed any time. There should be a first-aid kit on the job at all times.

Review Hazards. When all is ready for the actual operation to begin, the supervisor should alert the crew as to the main hazards in connection with the job, cautioning again about following only safe practices and guarding against carelessness due to the routine aspect of the job. It is not enough for the supervisor to say, "Work safely, don't get hurt." If it becomes necessary to change a pin in a chain and the employee starts to strike the pin without eye protection, the supervisor should stop the job at once until proper protection has been secured. To do otherwise reflects a lack of supervision. A workman will use eye protection if the supervisor has impressed upon him that its use is an essential part of every job where there is any possibility of flying particles. The supervisor should explain to the employee that the risk is too great for him to gamble with his eyesight.

The desire for self-protection is natural, if the hazard is obvious. Consequently, the less obvious hazards are the most dangerous because the workman often shrugs them off. For example, the catcher on a baseball team never gets behind the

batter without his mask. It is obvious to him that a foul-tip might strike his face. But the tiny particles from a grinding wheel are hard to see; consequently the worker tends to ignore them. The philosophy of personal protection has long been difficult to sell to employees to the degree desirable. So we must convince employees of their personal danger, rather than merely ordering them to take precautions.

Common Dangers. The use of catheads present many hazards. There need not be accident or injury from their proper use. A typical situation might be this: The unit operator is not in a position to see the man at the cathead. Thinking all is clear, the cathead is placed in motion and the man is trapped. If the cathead man can't be seen, some other employee visible to both the operator of the unit and the cathead operators should give signals.

Much safety is involved with the routine, the "old stuff." Thirty years ago a man was caught in a sandline reel while pulling the sandline. He died. In 1956, just two weeks ago, a workman was caught in a sandline reel, and the sandline made 15 wraps around his body. He died. This is an example of "old stuff" still causing accidents and killing people.

Still another common occurrence is involved with people being struck by tongs. This brings up the old admonition: Never stand in a position which is in the area of a swinging tong. Workmen know this but ignore it. Why? It could be because the lead man or immediate supervisor fails to see that an improper position is being taken by the worker, consequently he fails to warn him to move.

Unsafe practices or methods of work are not corrected at the beginning of the day only. They are taken care of at the time a condition presents itself. "Let's take five" is an old saying. It is a good method to stop an operation to call a man's attention to a hazardous condition. A supervisor misses a good bet when he doesn't take advantage of the opportunity to shut down operations if at all possible to illustrate a condition that could cause accident or injury or both.

Safety in Every Step. Every workover has its particular jobs, but from a safety standpoint, every step in each job has particular problems. Consequently, every work action must be given consideration. Particular jobs on a workover include killing a well, squeeze jobs, treating with oil, fracturing, casing repair, perforating jobs, etc. On some of these jobs a serious fire hazard is present. On other, a combination of fire hazards and high pressures exists. In another, premature firing of a perforating gun is a constant danger. Another particular condition that may be present is one involving poison or "sour" gas. It contains hydrogen sulfide in varying amounts. To work around it requires special preparation.

About Fire Hazards. On those jobs that present an extreme fire hazard, we must again talk about the plan of the job with crewmen. Each man should know exactly what to do if a fire should start.

The kind of protection and the amount of protection is basic. Too often there is not enough fire protection at hand and in too many instances the fire protection has not been properly placed. Emergency fire fighting equipment may be located too close to the source of fire, thereby making it impossible to secure for use. Usually the first mistake made is placing units that carry a source of ignition too close to the well or placing them in a position where the prevailing wind carries flammable mixtures over the unit. Cases are on record of workmen having been allowed to carry matches or lighters on their person. The habitual smoker can easily forget and light a cigarette.

Unit exhausts imporperly protected have been a source of ignition. Such things are too often overlooked. Checking the equipment in advance for safe operations could have prevented many expensive fires and loss of life.

Since the fire hazard involved around workovers is gas or oil, the most suitable fire extinguishing agent is dry chemical. The value of fire protection on an isloated job is the ability to put the fire equipment into instant operation. It is therefore essential that sufficient fire equipment be placed far enough from the well and the units involved that the extinguishing agent can be activated and moved into the fire. This affords not only protection for the employee but makes the job of fire fighting easier. Each unit carrying tanks of oil should be equipped with a fire extinguisher that is easily accessible. Fires are controllable if proper facilities are available when the fire starts.

Maintenance is one of the most neglected items affecting fire extinguisher operation. Many times an extinguisher doesn't work because it hasn't been refilled or the nozzle has become clogged, etc. Too often when the question, "How about your fire fighting equipment?" is asked, the reply is that it is in good condition. Yet a spot check may reveal that there has been little or no maintenance.

Fracturing. Fracturing is a job that presents both a fire hazard and the dangers of very high pressures. Accidents around these jobs often result from failure of equipment, from using pressures in excess of the maximum safe working pressure of the equipment involved. This comes from taking for granted that the nipple, the union, the valve or line is heavy enough for the job. Nothing should be taken for granted. Check and be sure.

Perforating. Serious accidents have happened on perforating jobs. The perforating gun has been fired prematurely resulting in fatal injuries. This is another place where teamwork is involved and is necessary if such accidents are to be

Specially Designed for
• Offshore Operations
• Tenders • Steamships
• Barges

UNIT MARINER

Designed to operate from a fixed mounting, the UNIT MARINER delivers dependable and economical performance aboard offshore equipment. Cargo is conveniently transferred from tender to platform.

THE NEW APPROACH TO CARGO HANDLING!

Meets all requirements for cargo handling from a fixed mounting as applied to ships, barges, or offshore oil platforms.

BEFORE

AFTER

Features incorporated in the MARINER design include: One-piece cast gear case — a protection against salt spray • Self-aligning centerpost trunnion • Turntable load rollers plus replaceable hook shoes • Large diameter roller path • Worm type independent boom hoist • Large diameter swing brake • Disc type clutches • Straight-in-line engine mounting with torque converter plus many other important features. The LIFT and CONTROL ability of the MARINER permits loading and unloading with speed and accuracy. The full range vision safety cab enables the operator to see what he is doing at all times. Here's a machine constructed for your type of Cargo handling. Get the facts.

Write for: Bulletin MO-200 for Offshore Platforms
MS-200 for Ships and Barges

The net results of converting from old type rigging: Speeds up cargo handling — reduces idle port time — cuts maintenance cost. These self-contained MARINERS operate independently of ship's power.

UNIT CRANE & SHOVEL CORP. UNIT MILWAUKEE WISCONSIN

UNIT CRANE & SHOVEL CORPORATION

6603 WEST BURNHAM STREET • MILWAUKEE 14, WISCONSIN, U. S. A.

A 8881-1PB

SHOVELS • DRAGLINES • CLAMSHELLS • CRANES • TRENCHOES • MAGNETS

prevented. There must be a step by step plan and precautions taken as the job progresses. Every detail of the job should be carefully checked before the next move is made. Static electricity and the use of radio equipment have been given as the cause of premature firing of perforating guns, but in most instances the human element is the greatest factor involved. There has been a failure to recognize an accident situation in the making. If it is believed that static might be involved, bonding and grounding is essential. If radio equipment will activate the gun, shut off the radio or move it to a safe distance. Step by step planning will go far to remove the human failure factor.

Personnel numerical limits should be strictly adhered to in any type of workover. Only the number of people required to carry on the functions of the job at hand should be permitted on the location. Serious accidents during specific well jobs have caused serious injury and many fatalities to observers and the curious.

Gas Poisoning. Gas poisoning is another condition that may be present in a workover. If the well produces hydrogen sulfide it must be determined what concentrations are present. Instruments are available to ascertain the amount. The allowable permissible concentrations for continuous work without respiratory protection is .002 per cent or 20 parts per million. When the concentration has been determined and it is above the allowable limits, protection must be used. The sense of smell is not dependable as H_2S paralyzes the nerves controlling the sense of smell. Hydrogen sulfide has an odor similar to rotten eggs. However, in high concentrations it will be too late to seek fresh air after having breathed one or two whiffs.

Proper gas mask protection is essential. The H_2S canister-type mask is approved for concentrations up to .005 per cent for a limited period but cannot be used in closed areas or where there is a likelihood of insufficient oxygen to sustain life.

A concentration of .005 per cent H_2S or above demands the fresh-air hose mask or a self-contained breathing apparatus.

It is important that people be trained in the proper use and maintenance of such equipment.

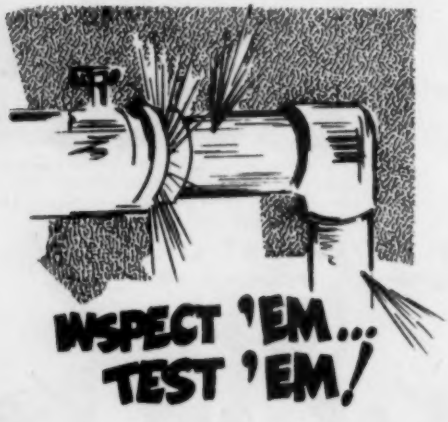
The foregoing discussion merely scratches the surface of what can happen on a workover job or what can be done to avoid accidents. It would be difficult to cite all the conditions that might be present, as every job presents different situations. It therefore is important that the basic philosophy of accident prevention be developed to the extent that each job situation will be analyzed with safety given equal consideration.

All Can Help. The worker must use his imagination and apply it to his work action in order to anticipate an accident situation. If his appraisal of the job to be performed reveals an accident situation, he must be given the privilege of questioning his fellow employees and supervisor in order that remedial action may be taken.

Supervision must show an active interest and have an attitude of helpfulness with workmen. The "why" and "how" of the job is the responsibility of supervision. It has long been recognized that one of the greatest responsibilities that goes with supervision is the development of a sense of security and confidence between the supervisor and the employee.

The function of safety people is advisory to supervision. The safety man's job is one of selling the safety policies and programs, and in order to do this he must realize that people are different. In his contacts with the supervisor, his tactfulness determines the enthusiasm with which supervision accepts his suggestions and criticisms. In the final analysis, the accident prevention program is only as effective and meaningful as the support given it by top management.

Two Important Factors. On a workover job or any other job for that matter accident prevention cannot be gained by lip service. In the progress of every job all eyes and minds should be looking for the accident situation. The prevention of accidents should become second nature on the job, for safety and efficiency go hand in hand. For any job to be successfully concluded these two important factors must never be divorced from each other. * * *



When you make your derrick man reach out and wrestle the elevator with every stand of pipe, you are wasting drilling time and money . . . and sacrificing safety.

If you don't have a Hook Positioner you're sacrificing Time, Money and Safety!

Here's where Byron Jackson's *exclusive* hook feature pays off. The BJ Hook Positioner automatically rotates the elevator into the correct position for the derrick man. Elevator handles and door are ready for instant, easy latch-on. There's no groping, grabbing and griping.

The BJ positioner consists of a cam follower which travels on a hardened cam track. The cam follower may be set and locked in any of 24 regular positions. Whenever the load is released from the hook, the cam follower travels upward until it contacts the cam surface on the housing. It then automatically travels on the cam surface and rotates the hook body to the predetermined position. This accurately locates the elevator door handles so that the derrick man can quickly, easily and safely latch-on the next stand.

Don't make a monkey out of your derrick man. Make your next hook a BJ Hook with *exclusive hook positioner*. You'll save money . . . with safety!

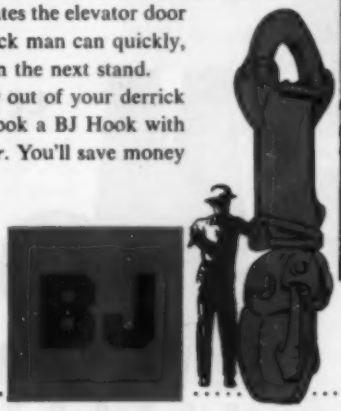
Here's How It Works!

Elevator at monkey board has door handles perfectly positioned for derrick man to load stand.

Going in hole, conditions such as crooked hole, bridges, etc. rotate hook body and elevator.

At rig floor, slips take load and BJ Positioner automatically rotates hook body to pre-set position.

Elevator is fully re-positioned into correct working position—for elevator opening at floor and for instant latch-on at board.



Watch BJ Red for the Newest

Byron Jackson Tools, Inc.

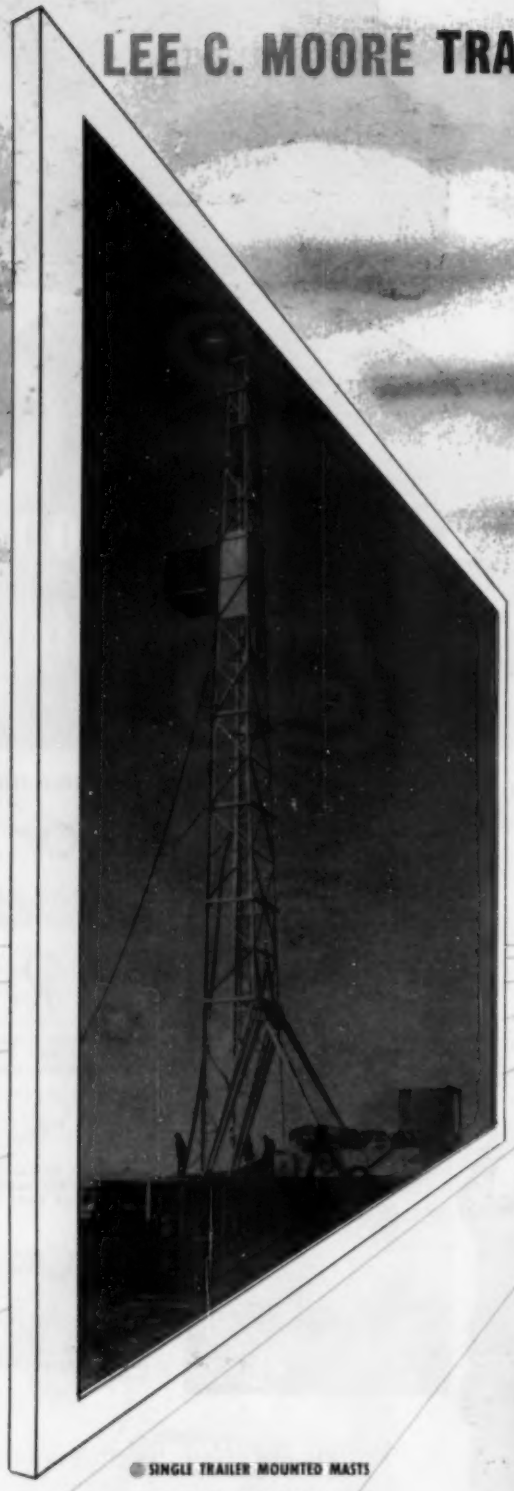
A Subsidiary of Borg-Warner Corporation

P. O. Box 2017A Terminal Annex, Los Angeles 54, California

Export Address:
580 Fifth Avenue, Suite 510
New York 36, New York

Offices in Houston, Fort Worth, Denver and New York

LEE C. MOORE TRAILER MOUNTED MASTS



DESIGNED
to fit your needs

Lee C. Moore designs trailer mounted masts to accommodate a wide range of drawworks and powers. Our close collaboration with other manufacturers assures the drilling industry of drilling rigs best suited to specific requirements.

SINGLE TRAILER MOUNTED MASTS

86 ft. 94 ft. 97 ft. 97 ft. Heavy duty 100 ft. 126 ft. Export model

DUAL TRAILER MOUNTED MASTS

97 ft. 100 ft. 126 ft.
126 ft. Export model

LEE C. Moore CORPORATION

TULSA : SHREVEPORT : GREAT BEND : CASPER : NEW ORLEANS
CENTRALIA : DALLAS : HOUSTON : MIDLAND : PITTSBURGH

EXPORT OFFICE:—ROOM 624, INTERNATIONAL BLDG., 630 5TH AVE., NEW YORK 20, NEW YORK

FOREIGN LICENSED MFR. OIL WELL ENGINEERING CO., LTD., CHEADLE HEATH, STOCKPORT, ENGLAND

Mineral Reserve Surveys Urged for Southwest

A Southwest Research Institute scientist warns that southwestern states may be missing many mineral possibilities because of outmoded information and inadequate financing of state geological surveys.

Dr. William B. Mather, author of the mineral section of the Southwest Resources Handbook, which will be published by the not-for-profit institution later this year, says that mineral deposits which were previously ignored have now become economically important. He urges communities and areas in the southwestern states to launch a program of charting possible deposits of these minerals.

He explained that many hitherto ignored deposits will be revealed in the Southwest Resources Handbook. However, he said full exploitation of the mineral resorces of the Southwest depends upon a program of systematic exploration.

Mather said many industries could be developed once these deposits are located and evaluated. As examples of the neglected minerals, he cited the case of the clays and sands which have just begun to be appreciated. These have led to a growing ceramic industry and their full value to the economy is still to be realized, he said. As another example, he pointed out that lignites (low-grade coal) will command an increasingly important place in the future economy of the area.

Mather showed that in 1952 a surprisingly small amount of money was spent by state agencies to chart these mineral deposits. For example, Texas, which is the largest mineral producing state in the country (more than 3.3 billion dollars in 1952), only spent 3.8 cents per thousand dollars of minerals produced. The small state of Maryland spent over 120 times this amount and Oregon spent nearly 100 times as much.

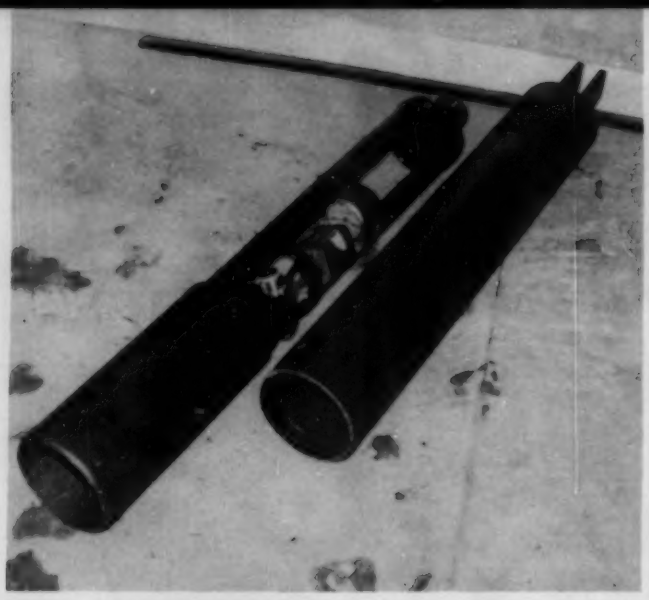
Mather suggested that if the states themselves do not act upon the problem, local communities should conduct their own mineral audits so they can benefit from the exploitation of these now dormant resources.

Big West Coast ASTM Meet

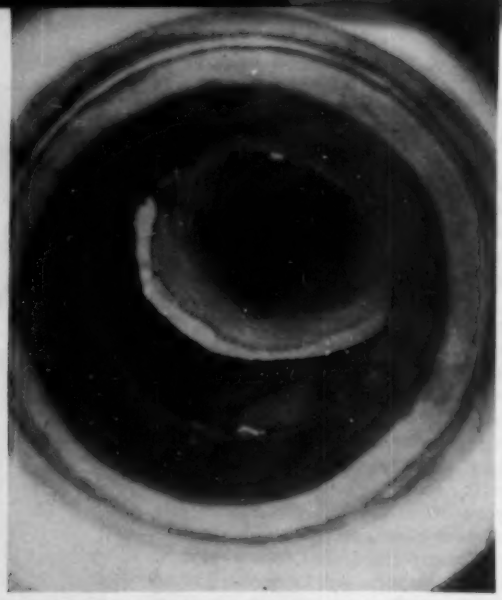
An outstanding technical program will mark the second Pacific Area national meet of the American Society for Testing Materials at the Hotel Statler, Los Angeles, California, September 16-22, 1956.

Program is said to be the largest in ASTM history and will cover practically all phases of industry of interest to society members. Sixteen symposia and nine special sessions will be presented.

what's the good word?
"Seeco-Mul"
Seeco-Mul Emulsifier makes a good mud better
In almost all areas, emulsion muds increase drilling rates, make better hole conditions, drill into pay formations better, afford better coring, and protect the pay zone from water more effectively. Such factors are easily projected into substantial cost and time savings, and mean longer service life for liners, collars, tool joints, bits, and drill pipe.
Seeco-Mul, added to the system 3-5 lbs./bbl., effectively disperses the oil content in an emulsion mud. It maintains a low filtration rate, has good wall building characteristics, contains excellent properties for maintaining the minimum viscosities in a system, makes better hole conditions, and better completions.
The table below shows actual savings that were effected by using Seeco-Mul. Each example compares a lime base oil emulsion mud and a Seeco-Mul oil emulsion mud in geological comparable formations. If you are interested in savings like these, ask your local mud dealer about Seeco-Mul. Your regular mud engineer can use it without special instructions or extra equipment.
MUD | TOTAL DEPTH | TIME ON BOTTOM | AVG. FT./HRS. | BITS USED | AVG. FT./BIT
Seeco-Mul | 9,011 | 191 | 47.2 | 16 | 563.2
Lime Emulsion | 9,150 | 399 | 22.9 | 24 | 381.3
Seeco-Mul | 8,750 | 225 | 38.9 | 17 | 514.7
Lime Emulsion | 8,700 | 334 | 26.0 | 18 | 483.3
Seeco-Mul | 8,295 | 207 | 40.0 | 17 | 487.4
Lime Emulsion | 8,650 | 373 | 23.2 | 20 | 432.5
Seeco-Mul
order Seeco-Mul through your local mud dealer
CROSSETT CHEMICAL CO. • Crossett, Ark.



This down-the-hole camera was shop-made to aid and speed gas well workovers. It was made from a 5 ½-in. bailer tube, a small camera, a small battery and an old style thermostat clock similar to those used on household heating units and two flash bulb sockets and reflectors.



This picture showing parted casing was taken in a gas well during a workover job. It is easy to see that the camera was a great aid to working over abandoned wells. Note that casing is out of alignment. Other down-hole photos will follow.

P 532.

New Ideas . . .

Unique Tools and Methods Used in Gas Well Workovers

Down-the-hole camera, cement bomb, and other improvised tools paid off in reworking ancient gas field for storage.

Sidney S. Galpin
New York State Natural Gas Corp.

Palmer H. Montgomery
United Natural Gas Co.

SPECIAL Well Workover FEATURE

THE process of reactivating a depleted gas field for underground storage presents many problems. First among these is the locating of abandoned wells where no surface evidence of the operation remains. Once the hole was found, the well was redrilled, and then either completed as a storage well, or plugged and abandoned in a manner that would prevent gas leakage and would conform with state laws.

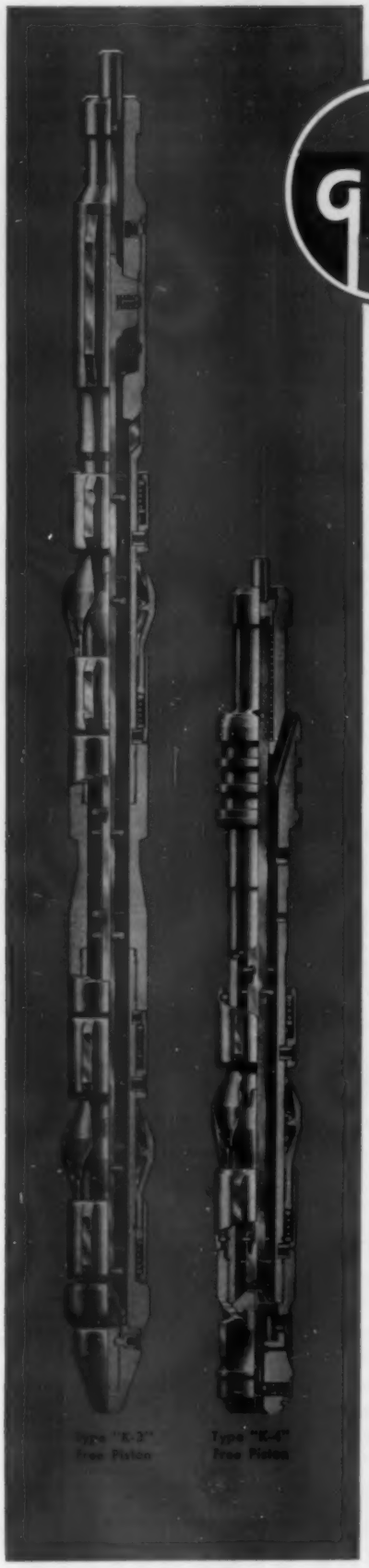
The second problem was that of reconditioning active wells to convert them into storage wells. This type of well had the initial advantage of being visible, but the process of reconditioning was often as difficult as redrilling.

The third problem in the well program was the location and drilling of new wells when this was necessary to provide a more effective spacing pattern.

Problems of Reconditioning For Storage

One storage operation in which New York State Natural Gas Corporation was engaged, involving the locating and redrilling of over 250 abandoned wells. Many of these wells were drilled and abandoned prior to 1900. Needless to say, much time and effort had to be expended in the location of these old holes. Houses had to be purchased and torn down, roads had to be detoured, buildings removed or undermined, and thousands of tons of earth and fill excavated. Some of the old wells were covered by as much as 18 to 20 feet of fill. To further complicate matters, an uncomfortably large percentage of the abandoned wells were drilled in the days when no records were kept. This meant that the redrilling had to be done "blind", with no knowledge of the total depth of the hole, hole sizes, casing program, formations penetrated, or method of plugging.

The modern well logging services came to the rescue at this point. Once the hole was open, it was possible to run various surveys and obtain the information that was needed. The gamma ray, casing collar locator, section gage, and



got

NEW! AUTOMATIC FREE PISTONS

With the NEW Flexible Metal Packer that assures higher efficiency . . . longer life . . . lowest maintenance

Everything is new about GOT Automatic Free Pistons! New designs . . . greater strength . . . improved performance . . . wider versatility for use in all types of wells. And newest of all is the *flexible metal packer* that gives new peaks of performance in all free piston operations.

This new packer has hardened beryllium copper sealing elements that interlay and form a pressure seal with only very light contact with the pipe walls. Spring-loaded and capable of movement in several directions, the sealing elements automatically compensate for irregularities in tubing size and roundness, and for the very slight wear to which they are subject.

This packer permits low lifting velocity, operates at low lifting differential, without loss of efficiency. It is the greatest improvement ever offered in free piston design!

Ask your GOT representative for complete information about the new GOT Automatic Free Pistons with the new flexible metal packer. In addition to the pistons illustrated, an economy-priced Type "E" is available, also, for use in gas wells and high pressure, high productivity fluid wells.

Garrett Oil Tools

P. O. BOX 2427 • LONGVIEW, TEXAS

USI

DIVISION OF U. S. INDUSTRIES, INC.
New York, N. Y.

temperature logs were especially helpful. The gamma ray log provides a stratigraphic record that could not be obtained otherwise in an old hole. This record was used for correlation of the formations penetrated, and from the correlated log it was possible to pick casing seats, locate points for packers or plugs, and set up a plugging program if the well was to be replugged. The casing collar locator, originally utilized for placing gun perforating shots, proved to be a most useful tool for determining the top and bottom of old casing in the hole, as well as finding the location of any other metal in the hole. The section gage plotted the hole size and acted as a verification of the top and bottom of old casing strings, as well as showing any holes or collapsed areas. It also indicated the location of caved zones and shot holes, and was helpful in calculating the amount of cement needed for casing jobs.

The temperature log was used to locate gas pays. Careful interpretation plus improvements in the sensitivity of the instrument eventually made it possible to pinpoint flows as small as 500 cubic feet per day at pressures as low as 8 psig. This information was essential to the casing and plugging programs. It would perhaps be amiss to state that the well conditioning program could not have been successfully completed without these services, but they saved time, money, and effort, and that the results were much better than could have been obtained in any other way.

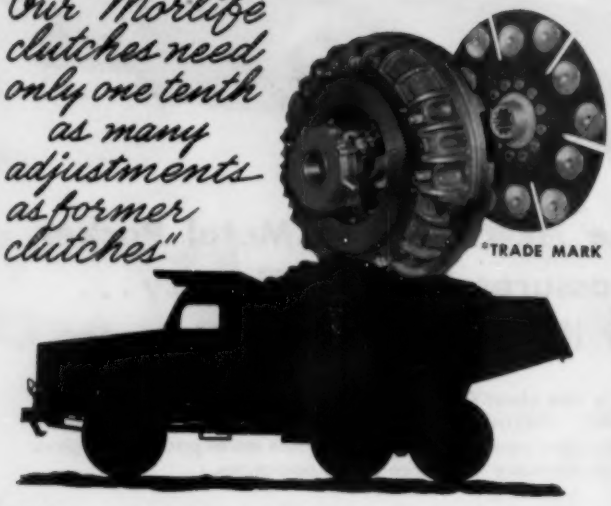
The actual redrilling and reconditioning was carried out in a normal fashion. Cable tool rigs were used. Some were fitted with shear poles for running and pulling casing, and some of the spudders had casing struts. No special equipment other than this was used on the rigs.

When the hole was first opened, a joint or two of 10-in. or larger casing was set to prevent caving at the top of the hole. Next, the largest bit that would run through the casing was used to determine the size of the hole, and also to see if there was any old casing near the surface. A smaller size bit and string of tools was then used to clean out the hole until a casing seat was reached. If the hole was clear and clean, a string of casing was run, and the operation repeated until some obstacle was encountered. If the obstacle was casing, it was sounded out and cut with a casing ripper at its lowest free

ROCKFORD

"Our Morlife clutches need only one tenth as many adjustments as former clutches"

*TRADE MARK



"MORLIFE clutch has gone 851 hours without slipping or adjustment."

"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

"MORLIFE pulls harder and lasts six to ten times longer."

"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

New MORLIFE* CLUTCHES and CLUTCH PLATES Give-

MORE Clutch Life (400% MORE)
MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

These *new* ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these *new* Rockford MORLIFE Clutches will improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

ROCKFORD Clutch Division BORG-WARNER
1303 Eighteenth Ave., Rockford, Illinois, U.S.A.
Export Sales: Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

The Authors

Sidney S. Galpin has been with New York State Natural Gas Corp. since 1951 and is production engineer and assistant superintendent of the vast Oakford District storage field. His studies of the Oakford field started in May 1950 when he was with Consolidated Natural Gas Company prior to the time New York State Natural took over the operation. From 1937 to 1950 he was with Peoples Natural Gas Company doing geological work. He graduated from West Virginia University in 1936 and served as graduate assistant in geology for a year.

Palmer H. Montgomery is storage engineer with United Natural Gas Company. He started with United in 1944 but took time out to serve two years in the U. S. Army and to graduate with a B S Degree in Petroleum from Marietta College in 1951. He also attended West Virginia University for a time. He is a member of the AGA's sub-committee on underground storage mechanics and the API subcommittee on hydrafracturing.

It takes a complete team to keep dependable drilling mud service available for you

Meet this Magcobar Man, the mud engineer... he's a good man to have on your drilling crew

The Mud Engineer is the member of the Magcobar team who gives you prompt, accurate laboratory analyses of mud at the well. His skill, knowledge, training and experience are at your command wherever you drill on the North American Continent. Trained and paid by Magcobar, this man actually works for you at your well.

When you have a mud problem your Magcobar Mud Engineer, with the entire Magcobar organization behind him, is the man to call. He'll be there anytime day or night.

Magcobar
Complete
DRILLING MUD SERVICE

MAGNET COVE BARIUM CORPORATION

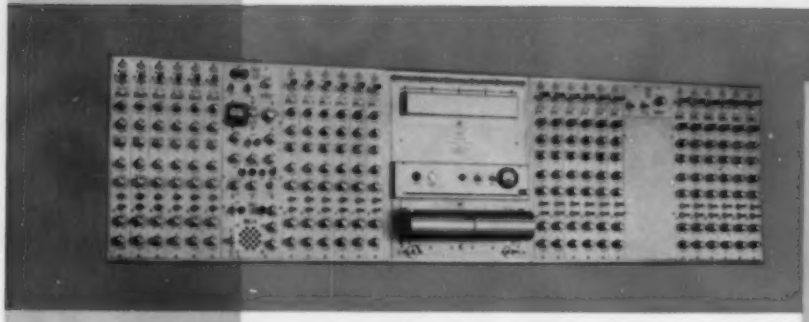
Houston, Texas

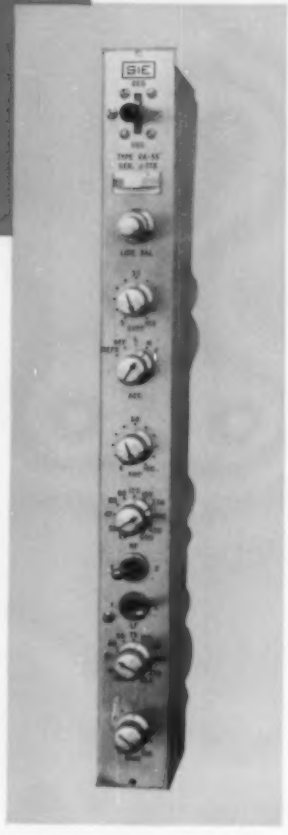
SERVICE INTEGRITY EXPERIENCE

SIE

REFRACTION
REFLECTION
HIGH FREQUENCY } **RECORDING**

with ONE seismic instrument





G-33 Full Spectrum
SEISMOGRAPH SYSTEM

SIE GA-33 Geophysical Amplifiers installed in an SIE G Series Seismograph System result in the widest range of recording applications ever offered the geophysical industry. In this small package are combined facilities for recording Refraction, Reflection, and High-Frequency seismic records . . . allowing the petroleum geophysicist to cover the entire seismic spectrum from 4 to 600 cycles-per-second with just one instrument.

Since the G-33 replaces three separate systems, it **cuts instrumentation costs in half!** In addition, SIE G-22A Seismograph Systems can be converted to Full-Spectrum operation simply by substituting plug-in GA-33 amplifiers and exchanging galvanometers . . . another example of SIE design forethought that lowers equipment costs for the industry's leading geophysical organizations.

ESSENTIAL TO A COMPLETE GEOPHYSICAL PROGRAM

Although SIE G-33 equipment exceeds any other seismograph in its capabilities and range of applications, it occupies only half the space required by many conventional single purpose instruments. With adaptability to every seismic exploration method, outstanding operating flexibility, and maximum field utility in terms of size and weight, the G-33 Full-Spectrum Seismograph System meets every requirement of modern exploration programs.

The GA-33 Geophysical Amplifier features Full-Spectrum filtering, variable AGC time-constants, and extremely low distortion (less than 1%). Its wide range is especially useful in magnetic recording applications, while plug-in construction permits simple installation and easy maintenance.

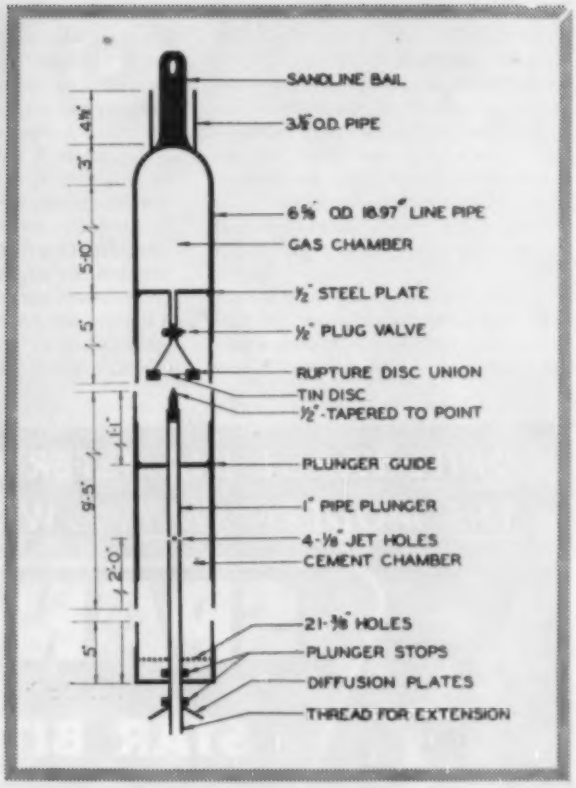
SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

P. O. BOX 13058
2831 POST OAK ROAD
HOUSTON 19, TEXAS

221 - 55

Some of the fish recovered from wells in the Oakford storage field.



Details of cement bomb.

point. Ordinarily the first fishing attempt was made with a trip spear. If the spear failed to do the job, additional cuts were made, and short sections fished out with a bell socket. The bell socket nearly always had to be used if the pipe had been shot or was collapsed or slivered. Many of these casing fishing jobs consisted simply of repeating the procedure outlined above, but often weeks or even months were required to remove a few hundred feet of pipe from the hole.

Tools lost in the hole presented another problem. When the tools were simply left in the hole, and occasionally when thrown in at the time of abandonment, they could frequently be fished out with a slip or combination socket. Many small objects were removed with a cherry picker. However, if the tools were abandoned in the hole after an unsuccessful fishing job, it usually meant drilling by the string, sometimes more than once, and then a long, tedious fishing job was necessary. The most useful tool again was the conventional combination socket. At times these sockets were modified by welding a "skirt" made up of two half rounds of the proper size pipe 18 or 20 in. long to the bottom of the socket. These "skirts" were flared out to the size of the hole, and helped guide the socket over the fish where the hole had been enlarged by drilling by or caving.

Naturally, in operations of the type described above, the tools used in the operation often became fast and had to be fished out themselves. One well had four strings of tools and a collar locator fast in it at the same time. Two of the strings of tools were eventually recovered, but the other two strings and the sonde had to be abandoned in the hole. Nearly every well redrilled had at least one fishing job.

The single item that caused more grief than any other was the cemented vent pipe found in wells plugged in accordance with the state plugging law. This vent pipe, commonly two-inch tubing, was run from a point 50 ft below the deepest mineable coal to the surface and cemented. This part of the hole was commonly at least 10 in. in diameter. The net result was that the vent pipe was practically impossible to fish out by any ordinary means, and attempts to drill up the vent pipe and cement simultaneously inevitably resulted in drilling out of the original hole. Once this occurred, it was practically impossible to get back into the old hole. A technique was finally devised that helped solve this problem. The vent pipe was cleaned out and a shot was then made up by stringing small sticks of dynamite between two lengths of Primacord. The sticks were spaced about six inches apart and fastened to the Primacord with friction tape. The shot, long enough to reach from the bottom of the vent to within 15 feet of the surface, was placed in the vent pipe which was then filled with water and the shot was set off. The explosion usually ruptured the vent pipe and shattered the cement around it. The cement could then be drilled out with a cherry picker, and the vent pipe picked out either with the cherry picker or with a tubing socket. If the vent pipe was too badly shattered to be fished out, it could be drilled up without losing the hole.

This method was successful on every well where it was used, and resulted in a great saving of time, as well as assuring the ultimate completion of the job.

Once the hole had been cleaned out, the formations correlated, the gas pays located, and the hole plugged back to the bottom of the producing horizon, if necessary, the problem remained of shutting off the gas in order to run and properly cement the casing.

One of the most tedious parts of a redrilling job was the matter of opening up a hole into collapsed casing or through iron or steel scraps that had been pounded down into a solid mass on top of a plug or bridge. A modified

bit referred to as a "punch" was used successfully in such situations. The "punch" was made by dressing the bit down from its usual size to a blunt chisel shape somewhat narrower than the body of the bit. This tool gave excellent results on casing and junk, but of course made no headway on tools or other solid material. Examination of the edge of the "punch" quickly showed the presence of any solid object in the hole.

Although most of the fishing was done with conventional tools and procedures, unexpected results were sometimes achieved in the process. A few examples will illustrate the point. Cherry pickers, used in cleaning out the hole where material seemed to be imbedded in the walls, came out with such diverse objects as a lead plug, a rope socket, a set of broken jars, a set of lay tongs, a ten inch spudding bit, an anvil horn, and many iron and steel fragments up to five or six inches in diameter which have never been identified. One fish, caught with a combination socket, consisted of another combination socket which had caught a dry-jar sub on which was a bulldog spear fast in a piece of seven inch O.D. casing, evidently left in the hole at the time of abandonment. One complete string of tools was found in an active well which had been completed about 1890.

The reactivating of a comparatively recent deep sand gas field for storage presents many problems that differ from those described above, and many additional ones as well. Tools and methods were improvised to overcome difficulties when conventional ones failed to do the job. In conditioning gas wells, persistence and hard work were the "order of the day". There was, however, little monotony connected with the jobs. One incident occurred while drilling a storage well in the Oriskany Sand. The drilling bit became unscrewed from the tools and was left at the bottom of the hole. With an open flow of approximately 12 million cubic feet daily, a friction socket was run into the hole to fish for the lost bit. As the tools were pulled to the top of the hole, the jars were held in a closed position by the gas pressure behind them. When the bottom of the socket came out of the casing, some gas pressure was released and the jars suddenly opened and the impact caused the lost bit, which was held in the socket by friction hold, to drop out. Instead of dropping to the bottom of the hole, the bit floated in the gas stream within about one foot of it above the top of the casing. The bit was held there by gas pressure which had backed up behind it. It bobbed up and down there for approximately one-half minute. Before the bit could be removed it slowly settled down just below the top of the casing and stayed there for several minutes. Efforts to remove it failed. Suddenly the weight of the bit overcame the gas pressure and it dropped to the bottom of the hole. The force with which the bit struck the sand further drilled the well in and the flow of the well increased to 15 million cubic feet. The bit was never recovered, and the hole was completed in that condition.

Special Tools

Cement bomb. Caving formations frequently give trouble in conditioning gas wells. One tool which was specifically designed to combat these caving formations was called a "cement bomb." It consisted of a 12 in. cylinder, 6 in. in diameter, and was divided into two sections. The top section of the cylinder was filled with natural gas at 300 psig pressure and the bottom section was filled with dry cement. The tool was run to the bottom of the hole or to the top of a bridge on the sand line, where the weight of the tool pushed a plunger which ruptured a thin disc. This released the gas pressure

DRILL LARGE DIAMETER HOLES
THE MODERN WAY . . . WITH

SPANG
FABRICATED
STAR BITS

Progressive Operators Everywhere Are Discovering This Modern, Better Way Of Drilling Large Diameter Holes.

SPANG FABRICATED STAR BITS replace the conventional, old-style spudding bit and the big hole paddle-type bit. They are made in large diameters for drilling hard formations, and can be dressed, ready for drilling, by hard surfacing quickly and economically, thereby saving the time consumed heating and ramming. Made in a variety of diameters, lengths and weights, with any size joint desired, SPANG Fabricated STAR BITS are your assurance of profitable **big hole** drilling.

For Extremely Large Diameter Holes
SPANG PILOT-TYPE REAMER BITS ARE RECOMMENDED

Field performance has amply proved these bits to be the driller's answer to **large hole** problems. They are made special, to your specifications and design, in any diameter; size and weight limited only by the handling capacity of conventional drilling rigs. They can be furnished to run on drilling stem or with integral rope socket top.

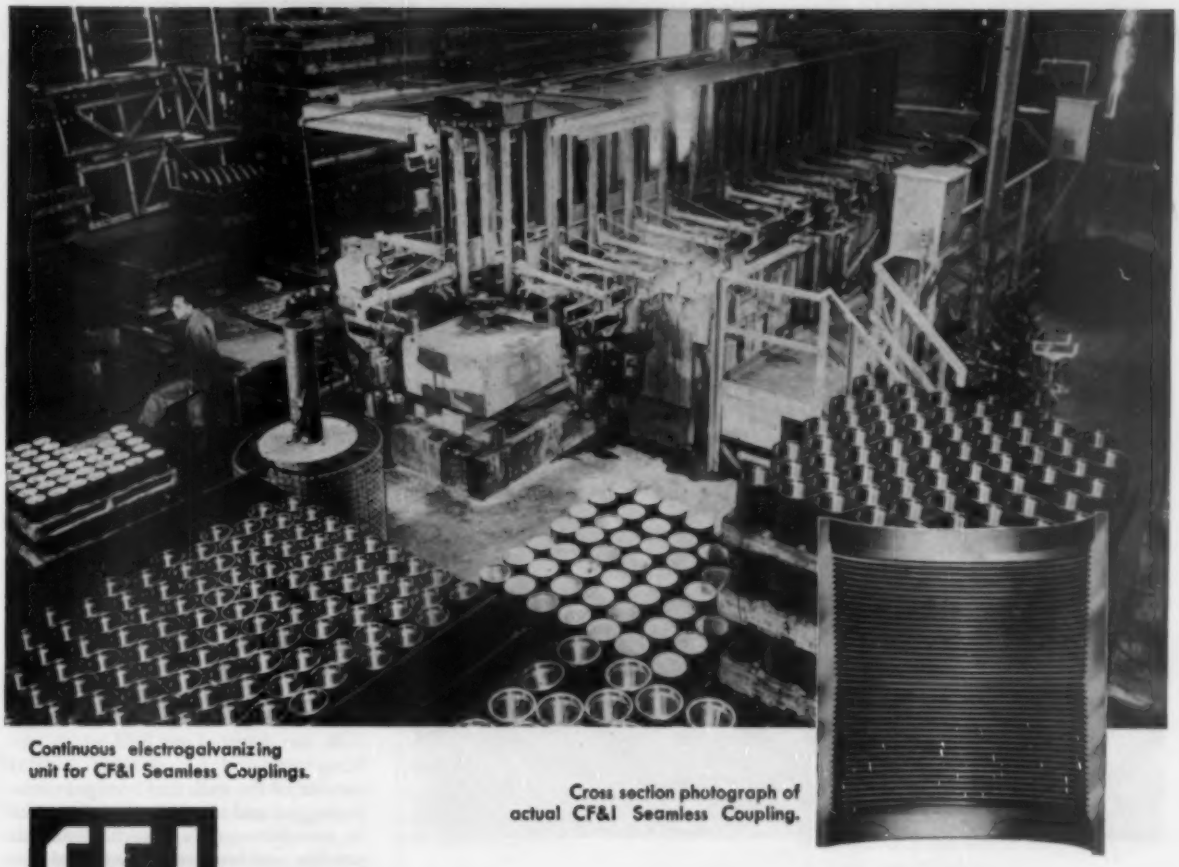
For detailed information on SPANG Fabricated STAR BITS and SPANG PILOT-TYPE REAMER BITS for big hole drilling, plus 52 page CATALOG, consult your nearest SPANG DEALER or write direct to

PILOT-TYPE REAMER BIT

SPANG & COMPANY

DEPT. O-7 BUTLER, PENNSYLVANIA

For over 60 years Manufacturers of Spang Weldless Jars and a Complete Line of Cable System Drilling and Fishing Tools for Oil and Gas Wells, Water Wells, Prospect Drilling and Shot Blast Holes.



Continuous electrogalvanizing unit for CF&I Seamless Couplings.

Cross section photograph of actual CF&I Seamless Coupling.

CF&I QUALITY COUPLINGS FOR SEAMLESS CASING AND TUBING

Rigid manufacturing standards, testing and re-testing are typical of the care CF&I exercises from mine through manufacture. These manufacturing standards assure Seamless Tubular Products of the highest quality.

The stresses imposed on oil country tubing and casing joints demand exacting manufacturing controls. One requirement in obtaining quality joints is to have a tight seal between the coupling and the pipe. This can be obtained only if the couplings and pipe are manufactured under the strictest specifications.

API Specifications require that all couplings must be processed to minimize galling. CF&I electrogalvanizes all couplings and exceeds this specification by carefully controlling the exact thickness of pure zinc—just enough zinc to prevent galling, but not enough to fill in the threads. This is just one example of the extra care which CF&I takes in the manufacturing process of their Seamless Tubular Products.

CF&I Seamless Oil Country Casing and Tubing meets API STD 5A Specifications—in sizes from 2⅜" O.D. through 9⅝" O.D.

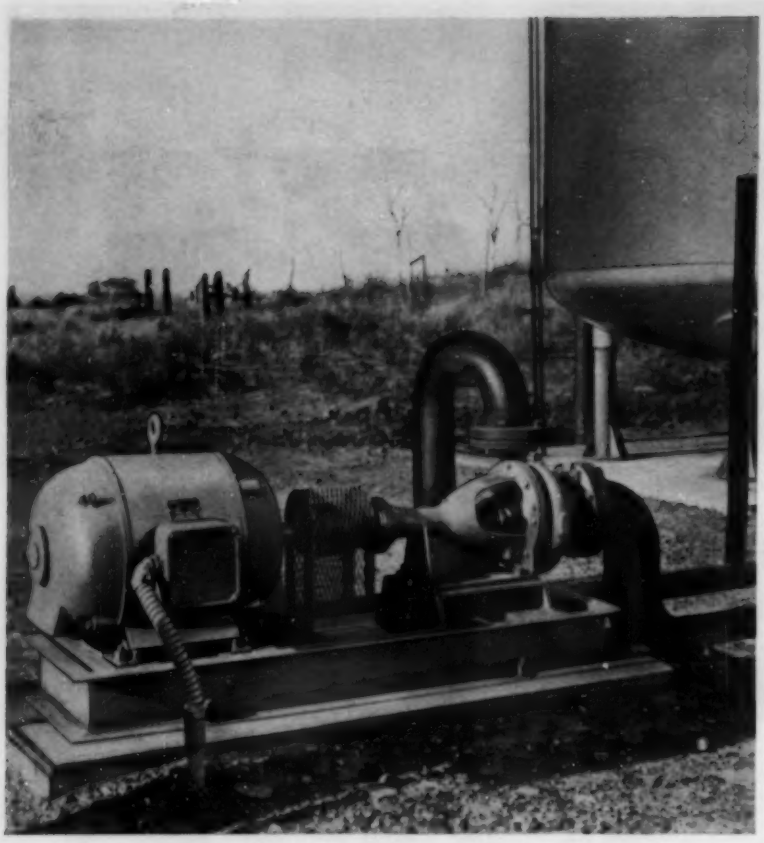
3894

SEAMLESS TUBULAR PRODUCTS

THE COLORADO FUEL AND IRON CORPORATION

Denver, Colorado

CF&I



A Centrifugal Pump Salt Water Can't Damage!

Ampco Pumps are ideal for salt-water disposal and flooding operations:

- *Transfer service*
- *Pumping over aerators*
- *Pumping through filters*
- *Back-flushing filters*
- *Delivery of treated water*

It's an AMPCO . . . made from aluminum bronze that contains no zinc.

Ampco Pumps resist corrosion, erosion, abrasion, cavitation-pitting, and dezincification. They are made from Ampco alloys engineered specifically to resist salt water corrosion.

Durability isn't the only advantage of Ampco Pumps. They have high efficiency . . . up to 85%. You pay considerably less for power.

Ampco Pumps are available in more than 100 different combinations, with speeds from 1750 to 3500 rpm; capacities to 600 gpm; heads to 300 feet.

Contact us in Milwaukee for the name of your nearest AMPCO PUMP DISTRIBUTOR.

AMPCO METAL, INC.

Dept. PE-9, Milwaukee 46, Wis. • West Coast Plant: Burbank, Calif.

THE METAL WITHOUT AN EQUAL

P-23

which forced the dry cement out as a spray, dusting the wet walls of the hole. This action caused a thin layer of cement to be formed on the walls. During the action, the bailer could be raised in order to dust a longer section of the hole wall. This tool worked to the best advantage when used as a preventive measure rather than a cure.

Pipe Basket

When it did not appear justifiable to drill up slips and other fragments of iron in a well and when the usual fishing tools would not remove them, a tool was devised for this purpose called a "pipe basket." A joint of 4-inch pipe was cut at one end into strips or fingers approximately three inches wide and 10 in. long. This joint was run on the tools by means of a pipe-to-tool sub. As it reached bottom and weight was put on it, these fingers closed, and in closing scooped in the material. In this manner a type of basket was formed, enclosing the slips or iron within. This tool was used successfully in several instances.

Guided Rasp

In one depleted gas field which was being prepared for storage, a great number of the wells had been previously plugged and abandoned. At the time of abandonment, as much casing as possible had been recovered by shooting or cutting the production casing just above the top of the cement, leaving a cemented casing stub in the hole.

To make the proper jointure between the new string of casing and the old casing stub, it became necessary not only to revamp standard cleaning out tools, but to invent new ones.

One method employed to make these jointures was called the "sleeve jointure" method. It consisted of running a string of new casing, on the bottom of which was welded a short sleeve of pipe having an I.D. greater than the old casing. As the pipe was lowered in the hole the sleeve telescoped over the stub of the old original casing left in the hole. It was obviously necessary to prepare the old casing stub by smoothing and straightening it with various tools. Usually the well hole was much larger than normal size at the depth of the stub so that guides were frequently used on tools to make certain that they were working at the proper place.

One of the most useful tools was a "guided rasp." A tool joint was made inin the shoulder of an 8-in. single blade spud. A guide consisting of 4-in. pipe, pointed on one end, was screwed into the tool joint and it extended 8 or 10 ft below the bottom of the spud. Fourteen inch horse rasps were welded on the inside of the blade of the spud.

Shop-made cement bomb aids in the control of caving formation. The bomb explodes dry cement on wet, caving bore-hole.

Cement bomb explodes in demonstration. This bomb is easily made from line pipe. The upper portion stores high-pressure natural gas; the lower half contains dry cement. When a plunger on bottom strikes rupture disc, the gas blows the cement out the bottom.

As a guide moved up and down inside the stub, the rasps worked on the outside. In this manner the outside of the stub was prepared for a sleeve.

Guided Swage

In swaging out the top of the old stub left in the hole at the time of previous abandonment, it was important to make certain the swage was continuously working inside the stub instead of outside and a guided swage was developed for this purpose. A tool joint was made on the bottom of the swage and a 4-in. guide approximately 4 ft long was screwed into it.

Frequently the top of the stub was off center from the rest of the hole and it was necessary to make offsets in the guide so that it would enter the stub. A "knuckle sub" was often used in conjunction with the offset guide for the same purpose.

Trial Sleeve

Before attempting to make a "sleeve jointure" to an old casing stub by equipping the bottom of a new string of casing with a "sleeve," a dry run was made by running a "trial sleeve" to make certain that the sleeve would go over the stub. The "trial sleeve," of slightly larger I.D. than the O.D. of the casing stub was run on the tools with a pipe-to-tool sub. It was equipped with many horizontal pins which sheared off if the sleeve went over the stub successfully.

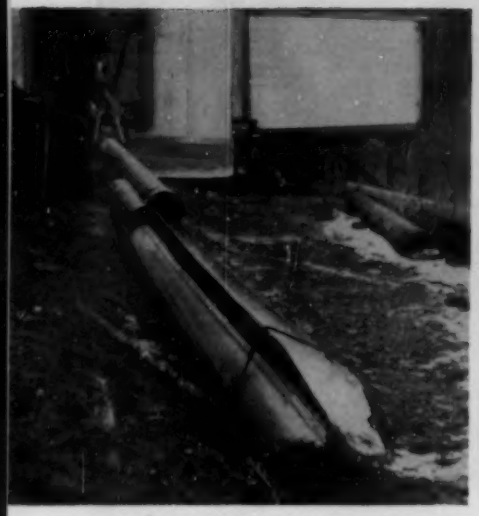
Magnesium Guide Pipe

In making jointure with old casing stubs it was frequently necessary to

Guided rasp. Horse rasps were welded onto an 8-in single blade spud.

Guided swage was made to swage out old stubs of casing left in abandoned hole.

Magnesium guide pipe was used to guide new casing onto old casing stub. In case the pipe could not be removed, the magnesium could be easily drilled.



Drilling tool guide was used to line up old casing that had been pinched off and displaced to one side.

Drilling tool guide ready to go in hole.

Under drilling bit has drilled 13-in hole below 10-in casing.

guide the new string of pipe so it would line up with the stub and thus make a proper jointure. This was accomplished by setting a stone bridge or magnesium plug approximately 25 ft inside the old stub. Then with a trip spear, smaller size casing, of magnesium pipe was lowered into the hole and into the stub and set on the bridge. This magnesium pipe was of sufficient length to extend above the stub to a point where the hole was normal size. The new casing was lowered into the hole and when it reached the "guide pipe," it was guided by the smaller size casing to the top of the old stub and properly centered. Magnesium pipe was used as the guide pipe because it could be readily drilled up in case the pipe could not be removed.

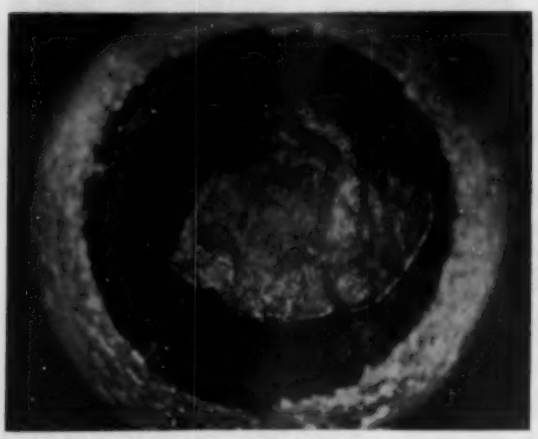
Magnesium pipe was also used in another manner. It was designed to be a recoverable or "pilot guide." In one well, a full string of casing would not go to the bottom because of a crooked hole. A pointed guide made of magnesium pipe approximately five feet long was partially filled with cement. It was riveted to the bottom of the casing with ½-in. pins. In this manner the casing was run successfully to bottom and the magnesium guide pipe was removed with a trip spear after first knocking out the pins with the bit. If the magnesium pipe could not be recovered, it could be drilled up.

Drilling Tool Guide

A drilling tool guide and an under drilling bit was developed while reconditioning gas wells.

In one well the 10¾ in. casing was pinched off and displaced to the side. In order to line up new 10¾ in. casing on top of the old casing left in the hole, a drilling tool guide was devised. This tool has an overall length of 37 ft. On the lower part of a 19 ft joint of 10¾-in. casing, a 24 ft joint of 10¾ in. casing was welded to act as a "pilot joint." This 24 ft joint overlapped the upper 19 ft joint for 6 ft in order to make a strong weld thus leaving the "pilot joint" 18 ft long. An 18 ft length of 10¾ in. casing was then split and welded into the pilot joint to act as a guide for the drilling tools. The bottom of the split joint was tapered on the back to facilitate its running into a "pilot hole" drilled alongside of the old casing in the hole.

In this well a 24 in. hole was reamed in an effort to find the top of the old casing. This procedure was not successful but by using other methods the top of the old casing was found. The



Sub-surface photo taken by the improvised camera.

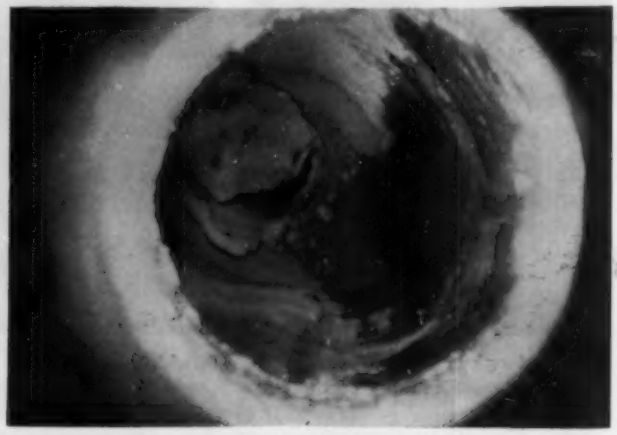


Photo of collapsed casing taken by the camera.

hole was enlarged outside the top of the 10¾ in. casing and a "pilot hole" drilled alongside of it. The "pilot joint," run on new 10¾ in. casing was lowered into the "pilot hole" outside the old casing, and the tool turned, forcing the guide against the old casing. In this manner, the new 10¾ in. casing was lined up with the old 10¾ in. casing so that cleaning out operations could continue.

Under Drilling Bit

This tool was made out of an 8-in. bit, one side of which has been truncated and dressed as a cutting edge; the other side, dressed to a tapered edge, extended below the cutting edge approximately 10-in. This tool was run through 10¾-in. casing and reamed a larger hole, up to 13-in., below the bottom of the casing. The extension acted as a pivot and the "bit-half" of the tool turned on this pivot, this reaming out a hole up to 13-in. in diameter. This tool was used as an under-reamer at a storage well which was being reconditioned. It was run through 10¾-in. casing to ream out a small block of cement which was preventing the new 10¾-in. casing from being lowered to a predetermined depth. The original hole was filled back and the block of cement was then reamed out with the under drilling bit and the new 10¾-in. string of casing was run to the proper depth.

Lowering Casing in Crooked Holes

In some crooked holes, it was possible to lower casing by rotating it. The pipe was rotated with the use of a large rotary table, the power being supplied from an engine of a spudding machine or tractor. As the pipe was rotated it was lowered with a casing outfit on a standard rig. This was rigged up in such a manner that the cable tools and rotary could be run alternately.

Air Pressure Test and Purging

To make certain that casings would hold high pressure, flow strings were tested with air for leakage and blowouts before the well was completed. A cast iron plug was set in the open hole or a magnesium plug set in the bottom joint of casing and capped with approximately five gallons of gel. To prevent a possible chance of an explosive mixture during the air pressure test, the hole was plugged of all natural gas. It was first loaded with 50 ft of water, then 125 lb of dry ice (CO_2) was broken into small pieces and placed in a bailer. The bailer was then run to the bottom. In approximately 20 minutes all of the

Reduce your Production Costs

two important ways!...

Fitted with a flexible and resilient ball guide, the PACIFIC Patented* API Ball Valve Cage lowers your production costs by—

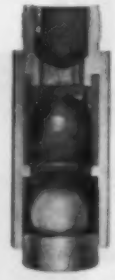
1 **Extending the use life of ball valve and cage.**

2 **Extending the runs between pulling the pump to replace worn valves, seats and cages.**

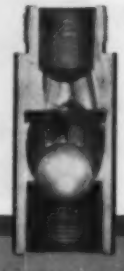
Why a flexible, resilient Ball Guide?

The difference in the capability of a resilient and a rigid material to absorb repeated shocks without permanent deformation is shown graphically by the unretouched photographs below. The ball valve cages are from the same pump.

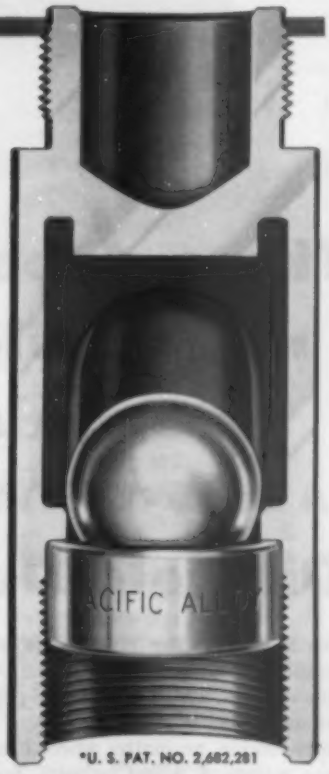
HERE IS THE ANSWER:
The PACIFIC steel ball valve cage, with a flexible, resilient ball valve guide bonded to the cage, *costs no more* than a standard steel ball valve cage, *yet it will give three to four times the service.*



A PACIFIC steel ball valve cage fitted with a flexible, resilient ball valve guide retains its original shape after 182 days of continuous operation. The ball valve is in good condition and may be easily removed from the cage.



A standard steel ball valve cage with hardened steel ball valve guides permanently deformed after 49 days of continuous operation. The ball valve cannot be removed from the cage.



*U. S. PAT. NO. 2,682,281

PACIFIC PUMPS INC.
HUNTINGTON PARK, CALIFORNIA
Export Office: Chanin Bldg., 122 E. 42nd St., New York—
Offices in all Principal Cities
Mid-Continent Division: 1221 E. 1st St., Tulsa, Oklahoma

PACIFIC®

DW15

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

ALLIS-CHALMERS ENGINES — 9 to 516 hp
diesel, gasoline, LP and natural gas, low-grade fuel
engines, power units, generating sets

B-125 — 27.8 maximum brake hp at 1,800 rpm
Choice of gasoline, natural gas,
butane or low-grade fuel.

These 2 popular engines now available through ALL ALLIS-CHALMERS Oil Field Dealers

W-226

60 maximum brake hp at 1,800 rpm
Choice of gasoline, natural gas,
butane or low-grade fuel.

The B-125 and the W-226 now are included in the complete line available from *all* Allis-Chalmers engine dealers. This means these popular models now are more readily available to you. It also means that every engine, no matter where it is working, is close to a source of Allis-Chalmers True Original Parts and approved service.

Many thousands of Allis-Chalmers B-125's and W-226's are daily proving themselves in applications throughout the oil fields. Over the years, they have built up an outstanding reputation for economical, dependable performance on production pumping, core drilling, cementing, spudder work and driving generators.

Ask your Allis-Chalmers engine dealer to show you the popular B-125 and W-226 — or other sizes and types of modern engines to meet your needs.

ALLIS-CHALMERS, BUDA DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

BO-2

dry ice had sublimated. This purged all natural gas from the hole.

As the dry ice sublimated, the gas mixture coming from the casing was periodically checked with an explosimeter to make certain that all natural gas was removed. After purging, the well was pumped to 2500 psig with a portable 4-stage air compressor. After pressure reached 2500 psig a drop pressure test was taken for 24 hours.

Sub-surface Camera

Perhaps one of the most useful and important tools developed was the "sub-surface camera." It was devised to take photographs down in the hole, not only to determine the condition of casing stubs and watch the progress of conditioning of stubs for jointure, but to determine the shape of other unknown objects found in the hole during cleaning out operations. To run the equipment in wells equipped with 6¼-in. ID casing, the camera was inserted in a piece of 5½-in. OD bailer tube to provide a protective shell for the camera unit and mounting. The camera unit consisted of a small camera, a small battery, and an old style thermostat clock similar to the type which has been used to turn a house furnace on in the morning and off at night, and two flash bulb sockets with reflectors. All of these items were mounted on a small aluminum strip which could be easily inserted and removed from the 5½-in. OD case.

The camera had a synchronized shutter and flash attachment whereby, when the shutter was tripped, the flash bulbs would flash at the instant the camera shutter assembly was open. The thermostat clock, used as a timer, was mechanically linked to the shutter trip lever and when a special timing disc tripped the thermostat control lever on the clock, the linkage tripped the camera. The special timing disc was made to replace the day and night time setting disc which was the original part of the clock.

The equipment was arranged for easy insertion and removal from the case in order to facilitate the replacement of flash bulbs, rolling film, and to allow resetting of the timing device.

The case was equipped with a bail that could be bolted into a bailer dart in the bottom of a bailer. The case was covered with a transparent water tight seal to protect the photographic equipment from damage from water and mud in the bore hole.

This equipment, after considerable experimenting and adjusting, operated with a reasonable degree of success and produced valuable information on conditions inside the well bore.

Since this tool was developed in the field, it is our understanding that at least one well servicing company has improved the sub-surface camera and has made its service available to operators.

Acknowledgment

This article is based on a paper originally titled "Unique Tools and Methods Used in Conditioning Gas Wells" by S. S. Galpin, New York State Natural Gas Corporation, and P. H. Montgomery, United Natural Gas Company, and presented at the spring meeting of the Eastern District of API at Columbus, Ohio, April 25-27, 1956.

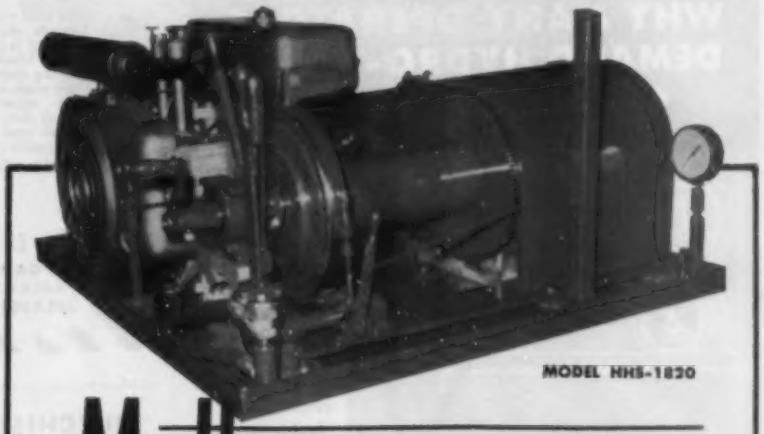
* * *

Oil Well Cementing Association Forms

The Independent Oil Well Cementing Association of America has been organized with Boyd Brazeel, Graham, Texas, named as president.

Fred Lynch, Seminole, was elected vice-president, and Johnnie Weaver, Oklahoma City, secretary-treasurer.

The association was organized to help companies keep pace with the latest developments and to share technical advances.



MODEL HHS-1820

Mathey MEASURING LINE REELS

The Oil Industry's First Name in Reeling Equipment
"Never a Compromise in Quality"

USES:
- Bottom Hole Pressures
- Temperature Surveys
- Calipering
- Paraffin Cutting
- Sampling
- And Many Other Wire Line Jobs

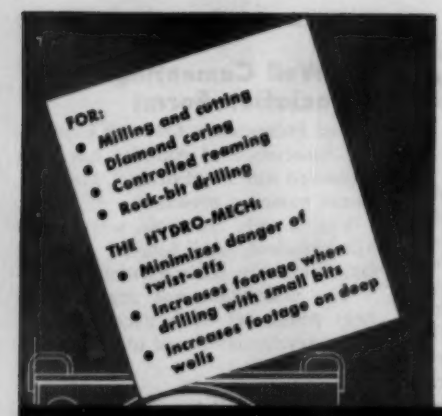
Mathey Reels are available in many sizes with various drives and controls in combinations to completely meet every requirement. Choose your type of control — hydraulic or mechanical, your capacity, your line speed and pull, and your type of power—hydraulic air, electric or internal combustion engine.

Mathey's many years of experience guarantee you extra heavy duty construction, precision machining, oversize bearings and forged steel drum flanges. Mathey also engineers and manufactures specialty reels to fit your individual requirements.

Call or Write for Further Information

SEE OUR CATALOG IN THE COMPOSITE CATALOG

C. A. Mathey MACHINE WORKS, INC.
212 SO FRANKFORT TULSA, OKLA. · PHONE Diamond 3-3623



Easily installed on any chain-driven rotary.

Responds to the slightest torque changes.

Adjustable for net-torque-on-bottom.

WHY MANY OPERATORS DEMAND HYDRO-MECHS ON ALL THEIR RIGS

Easy to move from well to well.

Stabilizes chain and gives it longer life.

Models for single or double-link chains.

The Hydro-Mech idler assembly rides under the rotary chain and transmits hydraulic impulses to a gauge in the drilling-control panel or in any other convenient spot.

Torque is one of the most important variables in any drilling operation — with too little, you're wasting men and equipment; with too much, you're courting an expensive twist-off. Recognizing these pitfalls, more and more contractors and operators are demanding that their rigs be equipped with Hydro-Mech torque gauges. Compared to a $10,000 fishing job, the cost of a Hydro-Mech is certainly negligible.

Distributed through Reed, National, and other recognized supply houses.

MARTIN-DECKER CORP.
HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

Proved Superior
IN GRUELING TORQUE AND PRESSURE TESTS*

FOR CASING AND TUBING

One trial will convince you that KOPR-KOTE'S *exclusive* formula combining copper flake with metallic lead and graphite is the *only real compound improvement in recent years!* Unexcelled as an anti-seize and positive leakproof sealing compound. Gives amazing low torque breakout after years of sub-surface makeup. Unaffected by vibration, surge, impact or shock. Prevents coupling distortion. Completely dams thread roots without ball-up. Will not settle out in container. *Write for further information or see Composite Catalog.*

**Send for Technical Bulletin #3.1 describing pressure and torque tests.*

JET-LUBE

Unconditionally Guaranteed

WHY GAMBLE? STOP LEAKERS WITH KOPR-KOTE

Sold Exclusively Thru Supply Stores . . . Everywhere

JET-LUBE, Inc. 3093 N. California St., Burbank, Calif.

HUTCHISON MANUFACTURING CO.
6609 AVENUE U, HOUSTON 11, TEXAS

ALWAYS IN OPERATION WHEN PUMPS ARE RUNNING

Subscription Order Form

The Petroleum Engineer,
Box 1589, Dallas, Texas.

(Enter) (Renew) my subscription for—

SPECIALIZED EDITIONS
☐ DRILLING and PRODUCING
☐ THE PIPELINE ENGINEER
☐ THE REFINING ENGINEER
1 year . . . $2.00 ☐ 2 years . . . $3.00 ☐
3 years . . . $4.00 ☐

MANAGEMENT EDITION
1 year . . . $6.00 ☐ 2 years . . . $10.00 ☐
3 years . . . $13.00 ☐

*Name*_____
*Company*_____
*Position*_____
*Home Address*_____
*Office Address*_____
*City*_____ *State*_____

SECONDARY RECOVERY
CABLE ENGINEERING
TECHNICAL CONSULTING
PRODUCTION ENGINEERING
SERVICE, INCLUDING
CORE ANALYSIS

PRESSURE MAINTENANCE WITH GAS OR WATER

MAKE EVERY DOLLAR COUNT!

REPRESSURING WITH GAS OR WATER

Utilize the services of experienced engineers to assure successful, economical secondary recovery.

SURVEYS
ESTIMATES
DESIGN
INSTALLATION
SUPERVISION

PETROLEUM ENGINEERS
CABLE ENGINEERING
WICHITA FALLS, TEXAS

"you fractured, too?"

Every oil magazine . . . every newspaper and news magazine . . . points up the tremendous job that Joe Roughneck is doing to supply the fantastic quantities of oil and gas required today.

Joe, symbolic spirit of the oil industry, may be on a rig in the field or running a company from the home office . . . but he knows oil and pipe.

We, at Lone Star, are glad to have him know, also, that we are enlarging our huge plant again in order to supply more API casing, tubing and line pipe.

Neighbor, wherever you are, specify Lone Star and we both get a good deal!

Lone Star STEEL COMPANY

LSS

EXECUTIVE-SALES OFFICES
W. Mockingbird Lane at Roper • P. O. Box 12236 • Dallas, Texas
DISTRICT SALES OFFICES
Houston, Texas | Midland, Texas | San Antonio, Texas
Tulsa, Oklahoma | Wichita Falls, Texas | Shreveport, La.

SPECIAL Well Workover FEATURE

MULTIPLE ZONE WORKOVERS

Royal W. Reiss, *Aluminum Company of America*

THERE is only one reason for making multiple completions and that is to produce oil into the tanks and gas into the pipe lines at lower costs. This is possible where one well can do for two or three and still be maintained at a reasonable expense. If a multiple completion cannot do this, it should not be used.

The way a multiple completion reduces production costs is through minimizing development well cost and through minimizing subsequent workovers. It is easy enough to see that if one well does for two or three, the development well costs will be lower. But the ability of a multiple completion to lower workover costs is not so readily apparent. As a matter of fact, this type completion requires additional down-the-hole equipment and in certain instances could actually mean added expenses in making future mechanical repairs.

Mechanical repairs constitute a relatively small percentage of the work done to existing wells, however; while the changing of completion zones and intervals accounts for almost half of the work done to existing wells throughout the industry. Thus, in the multiple zone completion where two or three of the productive formations are perforated and produced at the outset, two or three future workovers are eliminated.

Moreover, many of the mechanical troubles that require workovers have their origin in corrosion of tubing and casing. The producing of gas or oil simultaneously from two or three productive zones in the well means that the casing and the tubing in the well have a better chance of lasting the life of the reservoir without needing remedial repair from corrosion damage.

Too, many of the mechanical repairs of today are the result of poorly designed equipment of yesterday. Like many industries, the oil industry is a vast changing one because completion has made it so. Better equipment and improved methods have continually made inroads into new frontiers. They have made deeper drilling possible and better equipment has also made it possible for one well bore to serve to produce two or three zones — and possibly even more in the not too distant future.

To accomplish the latter it has been necessary to devise new equipment and to go against some of the practices which the old time well men thought not workable (principally because the new techniques were untried). The use of parallel strings of tubing for multiple completions is an excellent example of this and represents a long period in the oil field evolution from the simple open ended completions of yesterday.

Multiple completions are relatively simple when thoroughly understood. The keynote of any well equipment method of completion should be simplicity. In the words of the oil field it should be "roughneck proof." This ultimate goal probably will never be reached because unexpected field conditions or human errors will bring unanticipated problems. Every piece of equipment run into a hole is a calculated risk. More often than not, however, the equipment works just as it was designed to work (particularly when the conditions are those for which the equipment was designed). But occasionally equipment does fail and these failures are costly. Even so, when the overall picture is considered the cost is usually justified. **After all, the multiple completion should be always considered as two or three individual wells.**

In general, all workovers can be classified into two groups:

1. **Workovers necessary because of reservoir conditions.**
2. **Workovers to repair mechanical failures.**

In considering workovers in group 1, it must be pointed out that in most cases not more than four zones will be productive in one well bore. Consequently, on initial completions, all productive possibilities usually will be thoroughly evaluated and completions made if judged economical. All reservoirs will be depleted simultaneously; or looking at it another way most workover is done on initial completion. This has an economic advantage in that subsequent moving in and out of a costly workover rig is eliminated. Also it has allowed the operator to evaluate by the only true way — the production test — all the sands he could ever expect to produce from that given well. **Barring mechanical difficulty, no further workover should be required.**

For example, if one zone of a triple completion becomes depleted, before the other two zones, it would merely be closed in and mudded up if necessary. Or if the operator desires and the zone is the upper one, the two lower zones can be plugged off temporarily, the tree removed, and the top zone string of tubing pulled. The tree can be reinstalled, the plugs removed from the other two zones and the well placed back on production.

The big question in most operators' minds when considering multiple completed wells is the one of mechanical trouble. Naturally the more equipment involved the greater are the chances of failure. Where two or more parallel strings of tubing are used, a nearly impossible situation could be conjectured. But fortunately, most of our troubles never happen. Therefore only the more or less normal troubles will be considered:

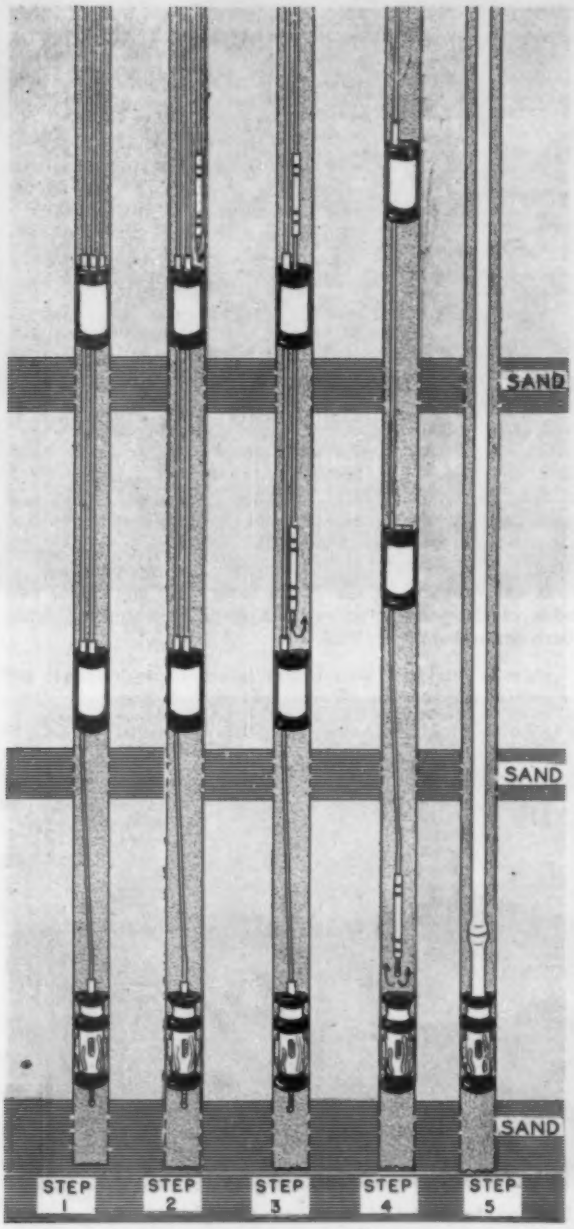
1. **Thread leak in tubing connection causing pressure build up on casing.** If such a leak occurs, particularly in a gas

The Author

Royal W. Reiss is chief engineer and general superintendent of the Oil and Gas Department of the Mining Division of Aluminum Company of America. He has been with Alcoa since 1950. Prior to this he was a petroleum engineer with Humble Oil & Refining Company, starting work immediately after graduating in petroleum engineering from Tulsa University in 1934. He took a leave from Humble during World War II to serve in the U. S. Navy.

well, it will have to be fixed. First, it must be determined which tubing string contains the leak. Pressure build up when flowing the different completions could give a clue. A temperature survey might locate the leak. As a last resort the individual tubing strings could be pumped full of fluid, one at a time, and the leak isolated in this manner.

If the leak is found to be in the number three string of a triple completion or number two string of a dual completion, the job would be simple. That tubing string could be loaded with water or mud and the other zone or zones plugged off inside the hanger nipple. The Christmas tree could then be removed, blow out preventers installed and the leaky string of tubing removed. Well pressure would remain on the other two strings and they will not be affected. The faulty tubing could be replaced and the tubing re-run and spaced. But before spacing the tubing into the top packer, it probably would be desirable to displace the mud with water or diesel oil and install a plug in the hanger nipple. The blow out preventers could then be removed, the Christmas tree installed and all three plugs removed which would allow all zones to start producing again. This particular workover would not differ materially from a single completion. But if one of the lower zone tubing strings has a leak, all tubing strings would have to be pulled. If the leak is in the middle zone of a triple completion, only the middle zone string need be pulled. However, it must be remembered that to obtain proper clearances, it is usually necessary to use integral point tubing with special threads so tubing leaks are not apt to occur.



1. **Triple completion in reverse:** Either of the two top tubing strings can be pulled without disturbing the upper two packers. In order to remove the packers, it is necessary to kill the well and pull the tubing string to the bottom zone. To remove the bottom, mechanically set packer, it is necessary to run drill pipe or tubing. Many of the workover operations such as acidizing etc., can be made with the tubing and packers in place.

2. **Sanding up.** If the upper zone should become sanded up, the well could be worked over just the same as outlined above — except that an extra trip would have to be made with sufficient small pipe on bottom to pass through the upper packer and wash down through the perforations.

3. **Acidizing or fracturing.** There is no reason why a multiple completion cannot be acidized or fractured just the same as a single completion. The main thing to be considered is the differential pressures which might occur across the various packers. For instance, suppose it is desired to acidize the lower zone of a dually completed well that has two packers and two parallel tubing strings. Formation break down pressures would probably be such that too much differential pressure would be exerted across the bottom packer. This pressure could not be applied by pressuring up the annulus because the top packer would be in the way. Therefore it would be necessary to apply pressure down the upper tubing string. A balancing pressure would also have to be applied in the annulus to protect the upper packer. These balancing pressures are doubly important in installations where differential, pressure-set packers are used.

4. **Packer failures.** Usually packer failures occur at the time of initial completions. Yet a failure can occur at any time if for some reason or other an excessive differential pressure is exerted across a packer. When this happens, all tubing strings must be pulled in order to repair the packer. The procedure to follow in removing the tubing and packers is just the reverse of the completion procedure and presents no great problem.

5. **Parted tubing.** If for any reason a string of tubing parts or a partial string is dropped into the well, a costly fishing job can result. However, it should not present an impossible situation because it should be possible to remove the good string or strings of tubing. It probably would be necessary to cut the complete strings off just above the top packer but several tools are now available which can do this at a relatively small cost. Thus there would remain, in the hole, only one string of tubing to be fished out with a conventional overshot. It would not be impossible for two or more strings of tubing to become wedged inside the casing so as to prevent pulling. This is a rather remote possibility but if such did happen, a diamond wash shoe could be used to cut its way down over the tubing and thereby free it. Successful washover jobs of this type have been done.

In general, workover jobs on multiple zone completions will be costly because more equipment must be handled. But the equipment is essentially the same as used in single completions and mechanical failures are not any more likely to occur. Most of the normal workover is done upon the initial completion. ★ ★ ★

EXPLORATION ACTIVITIES

KANSAS

★ Skelly Oil Company has reported good gas showings in a gas test 3½ miles north of Weskan in Wallace County. The well is 75 miles from the nearest oil production and is less than a mile from the Colorado state line. The wildcat has tested 1,200,000 cu ft of gas at a depth of 5200 ft. Some observers claim that test indications show well capacity of 35,000,000 cu ft of gas daily, although Skelly plans to drill ahead in an oil completion attempt.

★ Cities Service has released for drilling the Loewen "D" No. 1 test well on the 2040-acre North West Unger block approximately eight miles north of Peabody. The test is located in Marion County, and is two miles north of the Unger (Hunton Limestone) Pool, nearest production. Objective of the 2900-ft test is the Hunton limestone.

OKLAHOMA

★ Shell Oil Corporation has completed its Missouri limestone discovery in Beaver County with a daily potential of about 400 bbl daily. The well, six miles southwest of Logan, made 235 bbl of 39 deg oil in 13¾ hours through a 20/64-in. choke. Productive zone was from 5984 to 6016 ft. White Eagle International Oil Company drilled the well, the No. 1 Baldwin, to a total depth of 8632 ft and then plugged back to land 5½-in. casing at 6124 ft where Shell assumed operation.

★ A potential gas field in Beaver County has been redesignated an oil field with the recent completion of Union Oil of California's Neufeld No. 1 in the Southwest Boyd pool. The well came in flowing at the rate of 900 bbl a day of 37.5 deg oil through a ½-in. choke with an estimated 3,880,000 cu ft of gas. Production is from the Upper Morrow sand at a depth of 7154 ft. Union found the field this year with the Franz No. 1 as a gas producer that tested 7,500,000 cu ft per day with an estimated 75 bbl per day condensate. A second well, the Goosen No. 1, was drilled a mile to the south to determine the extent of the gas horizon. This was completed as an oiler, also in the Upper Morrow sand. It was then that the Neufeld No. 1 was drilled, a mile west of the gas discovery — another oiler.

★ Cities Service has staked a wildcat, the Sleeper No. 1-B, on the 4160-acre Northeast Eva block 25 miles northwest of Guymon, Oklahoma. The Texas County test has a contract total depth of 6000 ft with Morrow sandstones and Mississippian limestone as principal objectives. Nearest deep production is about four miles to the northeast.

★ A Caddo County test is finding good prospects in the Bromide sands and the McLish. Sinclair Oil and Gas No. 1 Susie discovery well brought flowing oil on drillstem test from the First and Second Bromide at 8744-91 ft at the rate of 50 bbl per hour. A test of the McLish (topped at 9153 ft and penetrated 250 ft) at a depth of 9393-9442 ft recovered 2000 ft of water cushion, 450 ft of 40 deg oil and 186 ft of gas and oil-cut mod. Tool was open 75 minutes; flow pressure ranged from 965 to 1065 psi, with shut-in pressure of 1985 psi. Crews are drilling ahead. The Susie is six miles northwest of production.

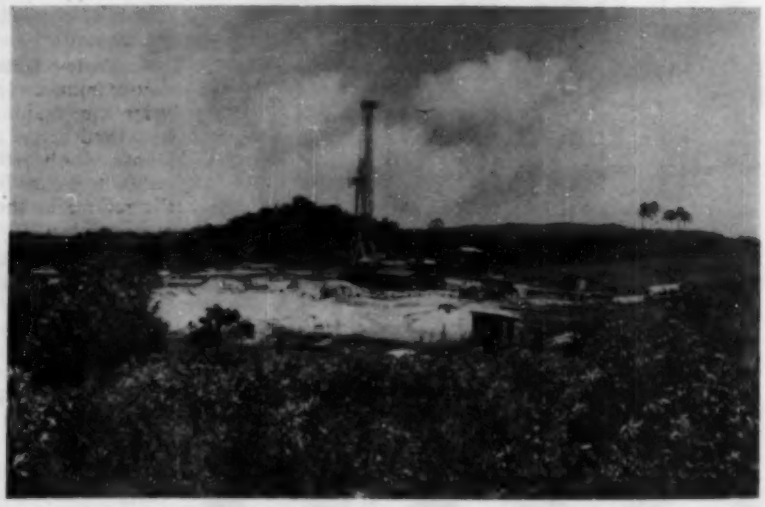
CUBA

★ Union Oil Company of California, and the Reiter-Foster Oil Corporation of New York will drill two new exploratory wells as a result of the signing of a letter of agreement covering operations of a 934,000-acre oil land mineral concession in Cuba. Under terms of the agreement, Union will within 30 days assume operations of the joint holdings which have been controlled by Reiter-Foster. Each company will hold a 50 per cent interest in the property. The agreement calls for all geological surveys and exploration to be performed by Union Oil for a minimum of three years at no cost to Reiter-Foster.

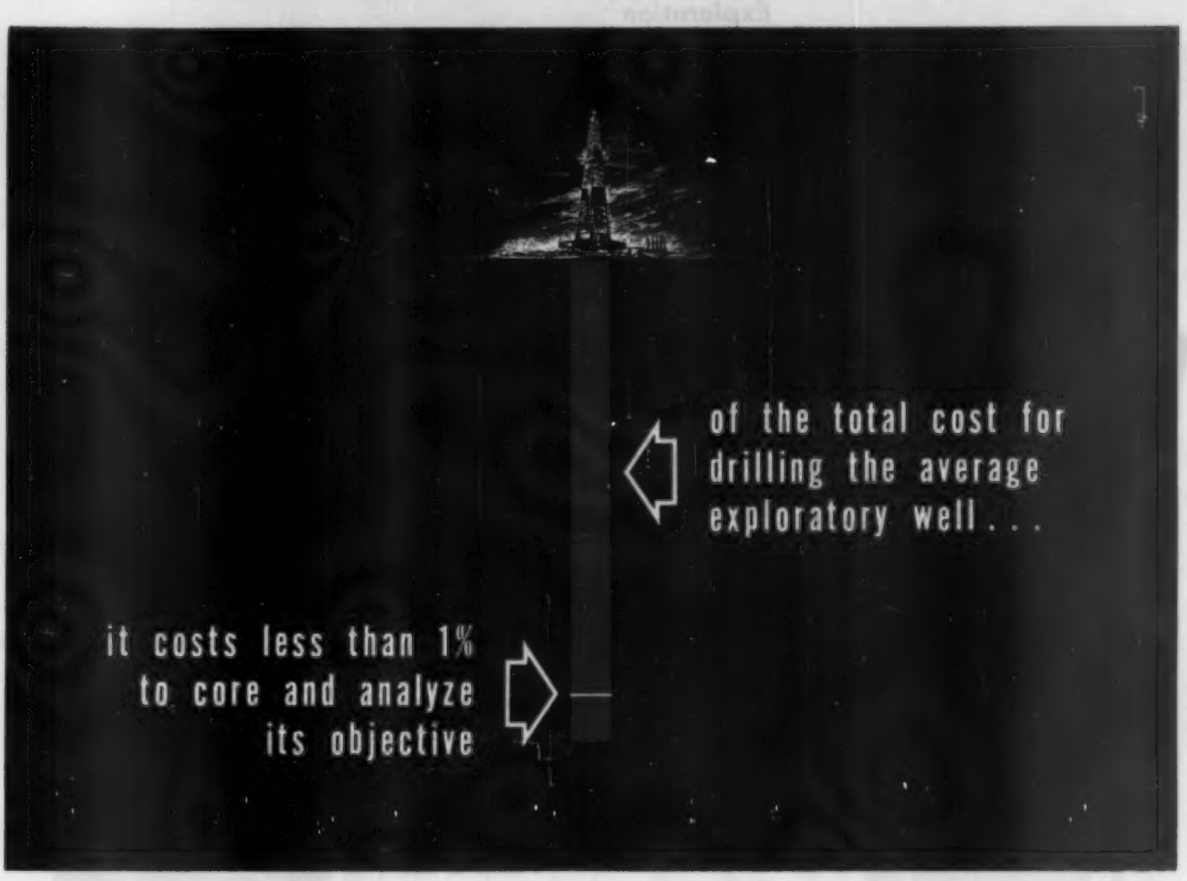
TEXAS

★ Cities Service Oil Company has completed its Waggoner "W" No. 1, a wildcat oiler in Wilbarger County. Drilled to a total depth of 3863 ft, the well flowed 764 bbl of 37.9 deg oil in a 24-hour period through a 24/64-in. choke. The well is producing from 24 ft of open hole in the Milham. Gas-oil ratio is 302 to 1.

★ Sinclair Oil & Gas has found production in a wildcat in Irion County about 2 miles from nearest established pools. The well is the No. 1 E. J. Cox. It had a flow of 168 bbl of 33 deg oil a day, through a 20/64-in. choke, from perforations in the Clear Fork at 4260-76 ft. The total depth is 4750 ft, with 5½-in. casing set at 4769 ft, plugged back to 4725 ft. Gas-oil ratio is 226 to 1. The Cox No. 1 is two miles east of the North Sugg field and about two miles north of the Metchum Mountain Pool.



First exploratory hole on the island of Jamaica is being drilled by Jamaican Stanolind Oil Company. Located on Santa Cruz mountain 2650 ft above sea level, Santa Cruz Well No. 1 is situated near the edge of a plateau that drops steeply over 2000 ft to the coastal plain below. Latest reports from the drilling location state crews are drilling ahead below 4512 ft in limestone and chert. Jamaican Stanolind is a wholly owned subsidiary of Stanolind Oil and Gas Company. Jamaican Stanolind has prospecting licenses on the entire land area of Jamaica and on offshore submerged lands to an average distance of 12 miles. Surface exploration work was begun in February. The well, which is about 60 airline miles due west of Kingston, was spudded on June 3.



We repeat — of the total cost for drilling the average exploratory well, *it costs less than 1% to core and analyze its objective.*

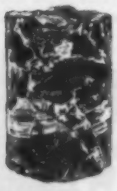
Add to the drilling cost those expenditures involving geophysical, geological, land, lease, and management overhead, and the comparative cost of coring and core analysis is negligible.

But what a difference the availability of basic reservoir information can make! Dollar for dollar, no single service or set of data offers more tangible results — both immediately and in the future.

For comprehensive evaluation of a formation's physical characteristics and potential productivity ability, for pin-pointing critical gas/oil and oil/water contacts, for establishing and maintaining controlled reservoir engineering, and for presenting acceptable data required in the financing or sale of reserves — *call Core Lab.*

There is nothing more realistic than the dollars you spend to reach a certain formation at a given depth. There is nothing more realistic for measuring the success of your risk than a direct analysis of the formation and its contents.

THE ONLY FULLY INTEGRATED PETROLEUM RESERVOIR ENGINEERING FIRM



CORE LABORATORIES, INC.

801 CORE STREET, DALLAS, TEXAS

CORE LAB

PETROLEUM RESERVOIR ENGINEERING

DALLAS, FT. WORTH, HOUSTON, CORPUS CHRISTI, McALLEN, SAN ANTONIO, MIDLAND, ABILENE, PAMPA, MONAHANS, LUBBOCK, LOVINGTON, SHREVEPORT, TYLER, EL DORADO, OKLAHOMA CITY, WICHITA FALLS, TULSA, ARDMORE, BARTLESVILLE, LIBERAL, ARKANSAS CITY, GREAT BEND, LAFAYETTE, NEW ORLEANS, HATTIESBURG, DENVER, STERLING, CASPER, WORLAND, KIMBALL, NEBR., FARMINGTON, BAKERSFIELD, LONG BEACH, CALGARY, EDMONTON, REGINA; VENEZUELA, S. A.

B and W Multi-Flex Scratcher

B and W Inc.
For a good cement job

B and W
Latch-On Centralizer

Also: B and W Multi-Flex Scratcher • Hinged Nu-Coil Scratcher • Rotating Scratcher, Multi-Flex type • Rotating Scratcher, Nu-Coil type • Latch-On Centralizer with Kon-Kave Bow • Latch-On Stabilizer • Stabilock

B and W Inc.
Well Completion Specialists

GULF COAST
Box 5266
Houston 12, Texas
Phone WA 3-6603

WEST COAST
Box 3751, Terminal Annex
Los Angeles 54, California
Phone DA 4-1106

6302

Exploration

LOUISIANA

★ Discovery of a new gas distillate field in Plaquemines Parish, in the Alligator Pass area approximately 20 miles south of New Orleans, has been confirmed after a second drillstem test. The wildcat, the Continental Oil Company Delacroix No. 1, flowed at the rate of 469 bbl daily of 46.8 deg condensate and 4,902,000 cu ft of gas through a ¼-in. choke at three intervals from 11,494 to 11,598 ft in the Miocene formation. Tubing pressure was 5425 psi and gas-oil ratio 10,450 to 1. Nearest production is more than three miles south of the discovery well. Conoco has a block of approximately 10,000 acres in the area.

★ A Canadian company, drilling its first well in this section of the U. S., has finaled a highly successful discovery and perhaps altered previously accepted oil and gas field geology of Bossier Parish, a major oil and gas producing area for the past 50 years. The well, brought in by Cardinal Drilling Company of Shreveport for Jaye Explorations, Ltd. of Toronto, Canada, brings the total of new wells in the buffer area between the Sligo and Elm Grove fields to three.

The Jaye well, which drillstem tested at better than 12,000,000 cu ft of gas flow, with heavy distillate oil content, has production from two zones in the Travis Peak formation between the 5900-6000 ft. Drilling for the new well discovered a new producing sand, named the Jaye.

As a result of the discovery Jaye officials plan an expanded drilling program in the area.

TURKEY

★ American Overseas Petroleum Limited (Amoseas), an affiliate of the Caltex Group of Companies, has completed plans to undertake test drilling on its recently acquired concession area in southern Turkey. Amoseas will drill the initial deep test at a site 30 kilometers from Gaziantep. Brown Drilling Company of Long Beach, California, is under contract for the project, and will use a large drilling rig being shipped to Turkey this month. Tentative plans call for spudding in the first test well around the end of this year. The Turkish Government granted fifteen permit areas in Turkey to Amoseas in April this year, covering a total of 2780 square miles. Eight of the areas are in southern Turkey. Others are in Thrace.

CALIFORNIA

★ Bolsa Chica Oil Corporation has started drilling operations on its Hartmann No. 101 well located in the southeast corner of the company's 60-acre Hartmann lease in the Ventura Avenue field. The upper zone test well is scheduled for a total depth of approximately 6950 ft with 7-in. casing to be set at 5700 ft; Terminal Drilling Company of Los Angeles has the contract. Productive zones in this property below 7528 ft are operated by The British-American Oil Producing Company which has 19 wells on production. Bolsa Chica owns a 40 per cent carried working interest in these deeper wells and 100 per cent of the working interest in the shallower measures where it has four old producers at present. Production possibilities in the shallow zones at this location led to the Hartmann No. 101 project.

Change Speed Reductions
QUICK!...

with a
JENSEN JACK

A JENSEN is without question the most versatile and practical pump jack you can buy.

Changing gear reductions, from single to double or from double to single, is a quick one-man operation requiring no major mechanical alterations and a minimum of downtime. The one-man counterbalance is another feature that adds to the functional design and economical operation of a JENSEN JACK. Get the details—see your dealer or write us.

JENSEN JACKS

JENSEN BROS. MFG. CO., INC.
Coffeyville, Kansas, U.S.A.
Export Office: 25 Broad St., New York City

SAVE 2 WAYS WITH

MARTIN RUBBER GUIDE CAGES

1. GREATER PRODUCING PROFITS *because:*

Martin Cages last much longer. The oil-proof rubber guides do the trick, by absorbing the ball peen hammer action of the hard balls. They also have superior resistance to sand abrasion. And they can be replaced.

2. GREATER PRODUCING PROFITS *because:*

Ball & Seat life is usually doubled, on the average. With the rubber guides, there is much less chattering, chipping and pitting. Ball falls true on seat. Such improvement in Ball & Seat life eliminates a lot of pulling expense.

In the last year alone, new users of Martin Cages have increased by 85%. The word is getting around. More and more economy-minded producers are learning about the advantages of the Martin Cages! . . . Manufactured in open and closed types . . . all diameters and styles. Write for John Martin Catalog No. 4 today. *Martin Cages are available through all supply stores.*

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

What's doing in DRILLING

★ **Louisiana drilling halt** is beginning to take its toll in rig shutdowns. In one week between August 13 and 20, Hughes Tool counted 21 additional rigs stacked in South Louisiana. In the August 20 rig count that numbered 2784 rigs actually turning to the right in the U. S. and Western Canada. Louisiana and West Texas literally "knocked the props" out from under large rig increases in Canada, Montana and California.

★ **West Texas operators** show reluctance in beginning new wells as a result of spreading crude price drops in the area. West Texas active rigs dropped in number from 350 to 339 late in August. The "uneasy situation" in the area has led several independent operators to trim their 1956 drilling schedules in the West Central Texas area.

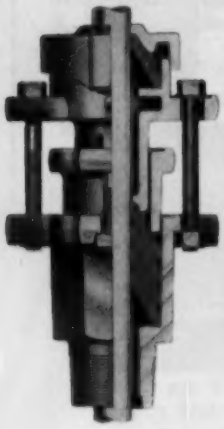
★ **Fourth tidelands well** by Signal Oil and Gas has been completed in the Redondo Beach area. The wells, first of a series, are being drilled into the city-owned submerged lands by Signal, as operator, with Reserve Oil and Gas and Arnell Oil and Gas as partners. The most recent well, the Redondo Beach No. 3, was completed flowing 95 bbl daily, cutting 3 per cent, through a 38/64-in. choke. Production is from a 425 ft interval between 3425 to 3850 ft.

★ **Turbodrill development** in the U. S. is expected to get an added spur with the merger of Guiberson Corporation into the Dresser family. H. N. Mallon, Dresser president, has indicated that the new organization will be an ideal place to manufacture rubber bearings used in the drill. The parent company has been negotiating in recent months with several foreign groups for techniques and U. S. rights.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	July 23	July 30	Aug 6	Aug 13
Alabama	8	8	9	9
Arkansas	20	20	19	19
Arizona	4	4	3	3
California	118	99	104	103
Colorado	54	57	49	56
Florida	0	0	1	1
Georgia	0	0	0	0
Illinois	84	78	82	78
Indiana	13	10	12	11
Iowa	0	0	1	0
Kansas	158	151	141	160
Kentucky	13	14	16	13
North Louisiana	65	66	69	68
South Louisiana	379	390	381	399
Total Louisiana	444	456	450	467
Maryland	0	0	0	0
Michigan	14	13	12	11
Missouri	1	1	1	1
Montana	47	45	44	43
Mississippi	25	27	29	30
Nebraska	33	32	26	29
Nevada	0	0	1	1
New Mexico	137	141	139	140
New York	0	2	1	1
North Carolina	0	0	0	0
North Dakota	25	26	28	27
Ohio	1	2	1	2
Oklahoma	278	259	259	270
Oregon	0	0	0	0
Pennsylvania	5	6	7	7
South Dakota	0	0	0	0
Tennessee	0	0	0	0
Texas Gulf Coast	266	258	252	227
West Texas	350	348	348	350
North Texas	315	290	306	294
East Texas	58	67	65	62
Total Texas	989	963	971	933
Utah	25	25	26	26
Washington	1	1	1	1
West Virginia	2	2	1	2
Wyoming	82	94	86	81
United States	2581	2536	2520	2525
Western Canada	265	247	238	241
Grand Total	2846	2783	2758	2766

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

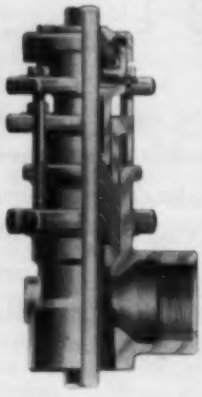


ONE OF THESE
Hercules Stuffing Boxes
CAN END YOUR PUMPING WORRIES*

"REGULAR TYPE" DUPLEX POLISHED ROD STUFFING BOX

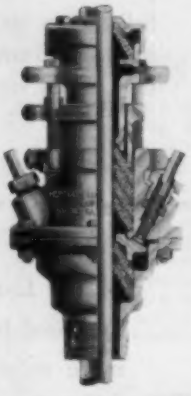
The old reliable, tried and proved on thousands of wells from coast to coast and in foreign fields.

HERCULES OIL RESERVOIR UPPER GLAND



"TEE BASE TYPE" DUPLEX POLISHED ROD STUFFING BOX

A combination Stuffing Box and Pumping Tee. Makes a short connection. Bolt lugs are placed low to eliminate fouling of elevator links. No bell nipple needed as top of body will support elevator. Full opening — unnecessary to remove body when pulling or running rods.



"TYPE DP" DUPLEX POLISHED ROD STUFFING BOX

A Double Packed Stuffing Box for use on high pressure wells and those that flow intermittently. Especially desirable for wells located near buildings, fire hazards of growing crops. Two compression bolts, in bottom sections, are tightened on Cone Rings to pack-off while replacing packing in upper section.

All HERCULES Stuffing Boxes are made of high grade malleable iron which prevents shattering if rods drop. They are tested to 3,000 pounds psi pressure and all use the famous HERCULES Split Cone Packing Rings.

* All HERCULES Stuffing Boxes may be equipped with Oil Reservoir Upper Glands on "problem" wells which pump-off and burn the packing. The polished rod moves through the oil in the reservoir which lubricates and cools it.

HERCULES TOOL Company
MANUFACTURERS OF OIL FIELD EQUIPMENT SINCE 1924
GENERAL OFFICES AND PLANT TULSA, OKLAHOMA
Export Representative: Oil Field Equipment Co., Inc., 30 Church Street, New York 7, N. Y.

for
western style
treatments

GO WESTERN

"Old West" remedies for ailing frontiersmen came from the western doctor, who traveled from patient to patient, dispensing "treatments" from his saddlebags.

Today, Western treatments for ailing oil and gas wells are administered by experienced well physicians – Western treating engineers. Just as the frontier doctor brought better health to the cowboy, Western revitalizes run-down oil and gas wells to bring production to a maximum.

Let Western put new life into your old well. And for integrated engineered well services—logging, perforating, fracturing and acidizing—completion or remedial, next time GO WESTERN!

THE WESTERN COMPANY

general offices: Midland, Texas

WESTERN Engineered WELL SERVICES

engineered well services

Texas: Odessa, Seagraves, Levelland, Snyder, Lubbock, Borger, Rankin | **Okla:** Lindsay, Healdton, Okla. City | **New Mexico:** Hobbs | **Kansas:** Ulysses, Liberal

493

COST CUTTING CASE STUDY

BERRY®
Hydraulic Units

New Drilling Method Uses Berry Units because:

- *Oil Field Reliability Proved*
- *Maximum Torque at Stall*
- *Infinitely Variable Speed*
- *Smooth Operation at Low Coring Speed*

Four Berry Hydraulic Motors mounted inside housings on drilling sub give rugged and dependable service.

PEMBINA CORING COSTS CUT 26%
with revolutionary BERRY-powered drilling sub

In the Pembina area south of Edmonton, Alberta, some way had to be found to take an uninterrupted core. Small iron was damaging the diamond core heads when drillers broke off the core and pulled out to make a connection.

A drilling sub, powered by Berry Hydraulic Motors was developed which makes possible continuous coring with minimum core damage from small iron because the bit never leaves the cutting surface.

Berry Hydraulic Motors develop the high torque required in this operation. Mounted around a ring gear, four Berry Motors directly drive the drill pipe at infinitely variable speeds from 0 to 135 rpm. *Power oil for the sub is supplied by "packaged" Berry Hydraulic-Pumping Units.*

The Berry-powered sub eliminates rotary tables, Kelly joints and rat holes. It has reduced average coring cost from $38.00 to $28.00 per foot . . . a saving of 26%. Diamond bit cost has been reduced an average of 37.5% with the new drilling sub.

Advantages gained: Rotary Tables and Kelly Joints Eliminated • Complete Core Recovery Without Removing Bit from Bottom • No Expensive Rat Holes are Needed • Continuous Coring is Possible • Coring Costs Reduced 26%

Want the full story on Berry Hydraulic Units?
Write for descriptive literature and catalog showing complete specifications on Berry Motors and Pumps for oil country use.

BERRY DIVISION
OLIVER IRON AND STEEL CORPORATION
PITTSBURGH 19, PA.

B-164

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Drilling

★ **Eighteen of 45** exploratory wells drilled this year in the U. S. by Standard Oil Company of California have been completed as new field or new pool discoveries. This record, reported by Board Chairman R. G. Follis, is double the 1955 national average rate.

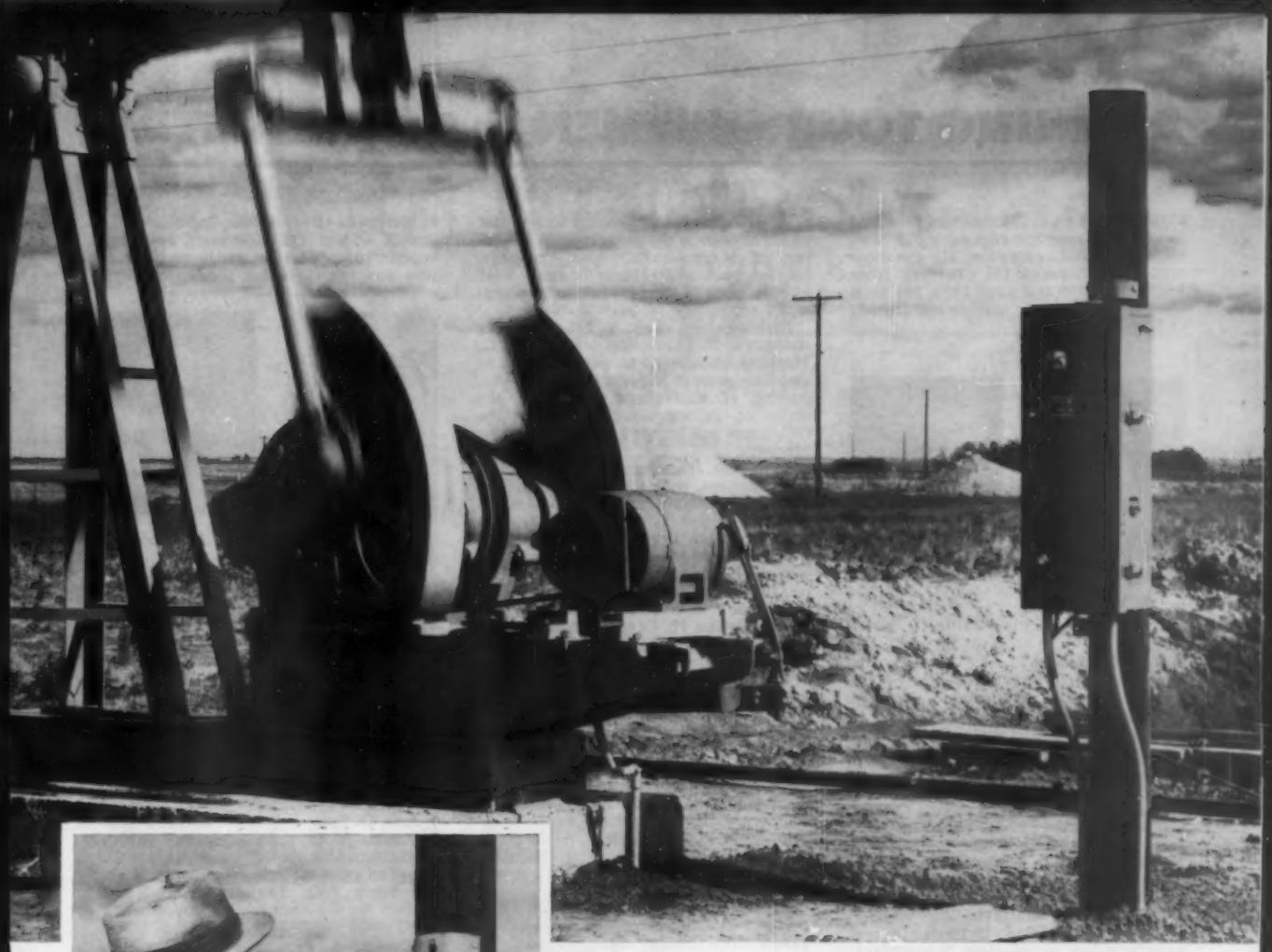
★ **Location for Sicily's second** test well to be drilled by the British Petroleum Company is now being determined by a seismic survey. BP's first Sicilian well was drilled near Vittoria in 1953 and 1954. Some crude oil was found but of such low quality that efforts to find a commercial use for it were unsuccessful.

★ **Twenty-six "deep" wells** have now been drilled in Israel, an official statement says. The government is now offering new incentive, including depletion allowance, to attract foreign capital in the development of its oil fields. The regulations allow companies to deduct a percentage depletion equal to 27.5 per cent of gross income from crude oil and natural gas production, provided the figure does not exceed half the net income for the taxable year. In addition, they may deduct cost depletion, an amount based on actual investment of oil and gas rights. There are now nine groups of oil companies operating on various lease spreads in Israel.

★ **Deepest production in Oklahoma** has been established at the Frankfort Oil Corporation No. 1, Pruitt, in Grady County. The well found gas in the Springer sand from 17,300 to 17,382 ft — about 200 ft deeper than existing deepest production in the state. The Pruitt flowed gas at the rate of 6,900,000 cu ft per day. Casing was set at 17,361 ft.

★ **Another offshore drilling company** is getting in the swim. Reading and Bates Offshore Drilling Company, Tulsa, Oklahoma, is entering the business with two large drilling tenders already under contract to the CATC Group operating in the Gulf of Mexico. The two new tenders, christened in August, are the "J. W. Bates" and "George M. Reading" and are built for 15 to 100 ft underwater drilling. Each of the vessels costs about $2,250,000.

★ **Veteran driller** T. W. "Tommy" Ward has formed a new contract drilling organization to operate out of Oklahoma City. Ward, who resigned as vice president of Schafer Drilling, plans to compete in all drilling depth classifications in the Mid-Continent area. The contractor will do business as Tommy Ward Drilling Company.



INSTALLATION, operation and protective features of G-E oil-well pumping starters are covered in GEA-6410. Contact your nearest G-E Apparatus Sales Office or Distributor for this bulletin, or write to the General Purpose Control Department, Bloomington, Illinois.

GENERAL ELECTRIC OFFERS . . .

2-WAY PROTECTION IN G-E OIL-WELL PUMPING STARTERS

G-E oil-well pumping starters provide electrical and mechanical protection for your equipment and personnel. Specifically designed for oilfield service, these features keep your wells flowing on schedule.

ELECTRICAL PROTECTION is assured against short circuit, lightning and undervoltage conditions. A fusible G-E HCI disconnect switch, with fuse clips that can be changed for other voltage or current ranges, helps protect against short circuits. A 3-phase arrester, solidly grounded, helps protect against lightning, and a high dropout relay guards against undervoltage conditions.

MECHANICAL PROTECTION is provided by the enclosure construction. The disconnect handle can be padlocked in the OFF position, and is interlocked with the starter door to prevent opening when power is on. The starter enclosure is sealed with a neoprene gasket to prevent the entrance of dust, rain and snow, and separate door permits checking or setting the combination timer without exposure to live parts. 733-18

Progress Is Our Most Important Product

GENERAL ELECTRIC

RUNNING TOUR with MEN in the INDUSTRY

James W. Law . . . elected vice president in charge of reservoir engineering of Nortex Oil & Gas Corporation. He was associated with Superior Oil Company from 1949 until 1956 and since 1956, has been chief of the reservoir engineering division of Nortex.

J. W. Law

J. B. Hudson

Joe B. Hudson . . . vice president in charge of exploration of Monterey Oil Company, named to the firm's board of directors. Hudson joined Monterey in 1953 and prior to that spent 20 years with Humble Oil & Refining Company.

Executive changes at Stanolind Oil and Gas Company are: **F. R. Yosta,** formerly vice president and division manager at Houston, Texas, to return to Tulsa, Oklahoma, as vice president, exploration. He will continue as a member of the company's board of directors.

Whitney M. Elias, formerly general superintendent, producing department, elected to succeed Yost. Elias has also been elected to the board. **Charles F. Bedford** . . . formerly division production superintendent at Fort Worth, Texas, succeeds Elias. **C. L. Larson Jr.** . . . division manager and director at Casper, Wyoming, and **George H. Galloway** . . . division manager and director at Calgary, Alberta, Canada, elected vice presidents.

Duval A. Davidson Jr. . . . became field superintendent of Stanolind Oil and Gas Company's Henderson area, transferring from producing department of Pan American Production Company in Houston.

O. W. Stanley . . . formerly with Pan American Production Company, joined The Chicago Corporation, as a geophysicist.

John L. Bible . . . named vice-president in charge of gravity, magnetic and radiometric operations of Southern Geophysical Company. With twenty years' experience, Bible was previously executive vice-president of North American Geophysical Company and recently president of Tidelands Exploration Company.

B. F. Hake . . . appointed general manager of Bolivian Gulf Oil Company, to headquarter in Cochabamba. He has 22 years of service with Gulf and has recently been special adviser for exploration for Western Gulf in California.

T. A. Pollard . . . promoted to assistant to the director at the field research laboratory of Magnolia Petroleum Company. He has been with Magnolia since 1947 as supervisor of the field research laboratory's production research division.

Magnolia also announced the following changes in its production division: **W. G. Moriarty** transferred to general office as assistant general superintendent of production. **H. K. Holland** will assume the duties of division superintendent of the Oklahoma producing division vacated by Moriarty.

I. B. Stitt Jr., assistant division petroleum engineer, promoted to division petroleum engineer at West Texas division, replacing Holland. **E. G. Thurman Jr.,** district petroleum engineer at Pegasus district, promoted to replace Stitt.

A. L. Larance, junior drilling engineer, transferred from Louisiana-Gulf producing division to West Texas producing division. **Dennis H. Cosper,** petroleum engineering assistant, now a senior petroleum engineering assistant in producing division at Duncan, Oklahoma. **E. L. Winterbauer** transferred from field foreman at Luling district, producing division, to petroleum engineer at the Kermit district.

Doyle G. Marrs promoted from petroleum engineer at Houston to district petroleum engineer at Pegasus producing district. **Wayne S. White,** junior petroleum engineer at Healdton district now a petroleum engineer there. **John W. Anthony,** research technologist at field research laboratories, transferred to petroleum engineer in the Dallas office.

Paul D. Irwin promoted from petroleum engineer to senior petroleum engineer and moved from Duncan district to the Oklahoma producing division office. **C. B. Johnston Jr.** promoted from petroleum engineer to senior petroleum engineer at Houston district. **Pat Kelly Norfield,** junior petroleum engineer, now a petroleum engineer at Vanderbilt producing district. **Duane G. Smith** promoted from junior petroleum engineer to petroleum engineer at Healdton producing district.

R. S. Hunt . . . district geologist for Cities Service at Roswell, New Mexico, appointed southwestern division exploitation geologist at Midland, Texas, succeeding **L. E. Patterson,** resigned. **M. F. Kennedy** of the Midland exploration office succeeds Hunt at Roswell as district geologist for New Mexico.

H. T. Tarvin

H. Thornton Tarvin . . . named vice president in charge of operations for the Delta Marine Drilling Company. Associated for 23 years with Loffland Brothers Company, he spent the last 6 years as representative of the contact and contract division in the New Orleans area. In addition to his responsibilities with Delta Marine, Tarvin will assist in management and operation of Delta Gulf Drilling Company, a wholly owned subsidiary.

Merton E. (Doc) Austin, and **Marvin L. Brown** . . . Sun Oil Company operating superintendents for the Michigan production and the Canadian production divisions respectively, have exchanged positions. **Lloyd E. Miller** will be assistant division manager for all divisional operations.

H. J. Weeks

S. M. Vauclain III

Herbert J. Weeks . . . appointed geological counselor for foreign operations of Sun Oil Company. Formerly he was head of the geological staff at the Philadelphia office, where he is replaced by **Samuel M. Vauclain III.** With Sun since 1939, Vauclain had been an assistant district geologist at Jackson, Mississippi.

J. G. D. Pratt . . .British Petroleum geophysicist, is to accompany the British Trans Antarctic Expedition which will attempt to cross the Antarctic continent via the South Pole. The expedition leaves Britain for the Antarctic in November.

William B. Moore . . . chief geologist for Atlantic Refining Company, will be manager of the company's new Louisiana Gulf Coast region, which will headquarter at Lafayette, Louisiana.

Other appointments for the region's staff are: **Bruce M. Choate** . . . exploration group manager for Texas Gulf Coast region, will serve in that same capacity for the new region; **William C. Allbright** . . . presently assistant superintendent of lease purchases, will be land group manager; **Barrett E. Booth** . . . general superintendent of drilling and production for Houston Oil, will serve as operations group manager.

Robert N. Kolm . . . named chief geologist to succeed Moore. Assistant chief geologist for the past five years, Kolm has been with Atlantic over 37 years.

Lester B. Swan . . . general manager, Brazos Oil and Gas Division, Dow Chemical Company, elected to the Dowell Incorporated board of directors. He joined Dowell in 1940 and its subsidiary, Brazos, in 1953.

Duane J. Magee . . . promoted to the position of landman and transferred to the Denver, Colorado, regional office of Lion Oil Company. Formerly chief scout for Lion in El Dorado, Arkansas, he is succeeded by **Jack M. Pierce,** scout at Lion's Billings, Montana, district production and exploration office.

Prior to joining Lion in 1952 Magee was a range manager for the U. S. Soil Conservation Service.

Over
60
Locations in the United States and Canada

McCullough® REPORTS
TO THE OIL INDUSTRY

Service
Anywhere Anytime

New Services • • • New Tools • • • New Methods • • • Outstanding Results

McCullough Tracer Log Shows Where to Shut Off 300 B/D Water Entry

The accuracy of McCullough's Radiation Well Logger and the value of McCullough isotope injection methods and tracer logging techniques were recently demonstrated in this Rocky Mountain area well.

The well was originally completed as a good oil well. Shortly after completion water broke in and killed the oil production. Rate of water entry was 300 barrels per day. At the producing horizon 5½" O.D. 14.5 lb. casing had been cemented in 9" hole.

McCullough was called to run their Isotope Injector and logging instrument to attempt to locate the point of water entry. A channel was discovered in the cement behind the casing. Also, there was a channel from one interval of the sand, which was the producing horizon, to another interval which was water bearing. Depth of operation was between 4650' and 5072'.

The well was squeezed and is once again a good commercial producer. This tracer job required only 5½ hours to complete. Locating a point of water entry is often difficult if not impossible to do. In this instance, well conditions and the efficiency of McCullough instruments permitted the successful completion of the job.

HAVE YOU RECEIVED YOUR COPY?

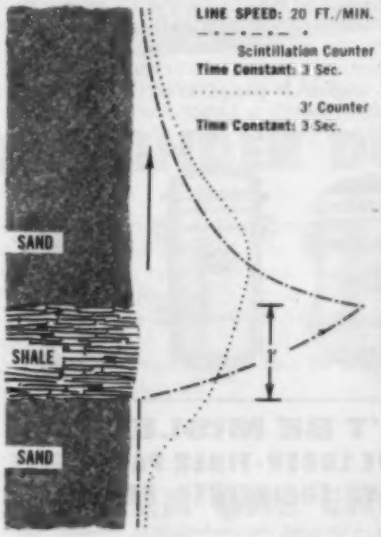
For Technical Paper on "Application of Radioactive Isotopes in Water Flood Operations"—Write McCullough Tool Company, 5820 South Alameda Street, Los Angeles 58, California.

Fifteen Borderline Wells Turned Into Profitable Producers

Precision Logging with McCullough's Scintillation Counter and Pin-Point Accuracy in Perforating Resulted in 645 B/D Increase in Production

Extra profits from only two days of increased production more than paid the entire costs of all McCullough Radiation Well Logging and Perforating Services according to the operator of this work-over project.

This company was producing fifteen borderline wells whose average production was 7 barrels of oil per well per day. Depths ranged from 3000 to 6000 feet. All wells had been electrically logged at the time of their original completion.



Illustrating the accurate definition obtained by McCullough's scintillation counter. Above shows the ideal response that would be obtained in measuring a thin bed with the scintillation counter and with a long counter. Note that, because of its short length, the scintillation counter exactly defines the boundaries of the thin bed, whereas the reading of the longer counter is an average of the radiation over the entire length of the counter.

Wells were re-logged with McCullough's Radiation Well Logger and it was found that there was as much as 17 feet of difference between the measurements obtained by the two types of logs. Also, several new zones were located that had been missed by the other logs.

Depending upon which perforating process would prove most effective for individual well conditions, the fifteen wells were shot with either McCullough M-3 Bullet Guns or Glass Jet Perforators.

Shooting the new zones disclosed by McCullough Logs and reperforating the old zones with McCullough depth corrections increased production to an average of 50 barrels of oil per day per well—a total gain of 645 barrels for the 15 wells. This was a highly profitable project.

McCullough's Radiation Well Logger, using the highly efficient scintillation counter, will give you the most informative, most accurate Gamma Ray and Neutron Logs available.

McCullough® TOOL COMPANY

Cable Address: MACTOOL

LOS ANGELES
HOUSTON
EDMONTON

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

B-167

STANDARD OF THE INDUSTRY SINCE 1936

Luber-finer

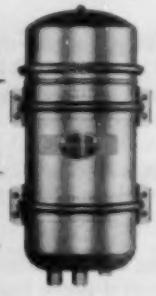
FOR EVERY TYPE OF ENGINE EVERY TYPE OF OIL

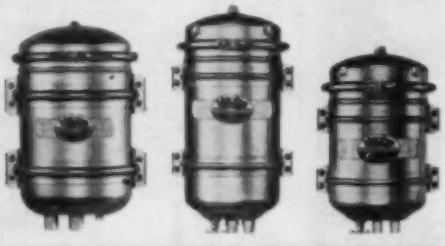
STANDARD and OPTIONAL EQUIPMENT ON LEADING DIESEL TRUCKS TRACTORS & STATIONARY ENGINES

Only a Luber-finer Filter Unit with a genuine Luber-finer Pack produces the patented filtering process that gives engineered protection to engine and oil as recommended by equipment manufacturers. The vital oil supply is circulated through Luber-finer's exclusive specially processed media which removes not only the injurious suspended solids from the oil but also the colloidal impurities which are often more damaging, thus increasing the life of both engine and oil. *The Efficiency of Luber-Finer's Patented Process has never been equalled!*

Luber-finer's patented filtering process adds thousands of miles to engine and oil life—cleaning—filtering—and returning the oil to the engine with the excellent lubricating qualities as specified by the manufacturers of today's modern high powered engines. Every minute—every mile your engine is run it must be protected.

Remember, there's a Luber-finer model especially designed for your type of engine or oil.





DON'T BE MISLED! ONLY GENUINE LUBER-FINER PACKS GIVE EXCLUSIVE ENGINEERED PROTECTION

DIESELPAK — Designed for use with H.D. detergent compounded oils. May also be used with fuel oils and straight mineral oil. Removes impurities and contaminants—without affecting the additives.

REFINING PACK—Designed for use with straight mineral oils; fuel oils, hydraulic oils and inhibited industrial oils.

The Refining Pack, which combines ABsorbent with ADsorbent filtration, removes acids, moisture, suspended particles and colloidal impurities during its effective life more efficiently than any other filter.

WRITE FOR COMPLETE INFORMATION DEPT. 8

LUBER-FINER, INC. 2514 S. Grand Ave., Los Angeles 7, Calif.

Running Tour

▸ **Dewey E. Williams** . . . appointed superintendent of land and inland barge operations of the Louisiana division of Loffland Brothers Company. He was superintendent of the company's operations in Eastern Venezuela.

▸ **Harold S. Thomas** . . . regional geological engineer for Phillips Petroleum Company, retired and will continue as a consultant for Phillips and others in geological phases of engineering work.

▸ **Clarence G. Matthews** . . . formerly drilling engineer with General Petroleums of Canada Ltd., joined Seaman Engineering & Drilling Company Ltd., as general drilling superintendent.

▸ **R. D. Roberts** . . . named district manager of Sohio Petroleum Company's new district in Calgary, Canada. Other appointments are: **Gordon L. Christie,** district landman; **Dr. Rein deWit,** district geologist; **N. W. McGee,** district geophysicist; **Dr. Philo Wilson,** staff geologist, and **D. J. Fraser,** geologist.

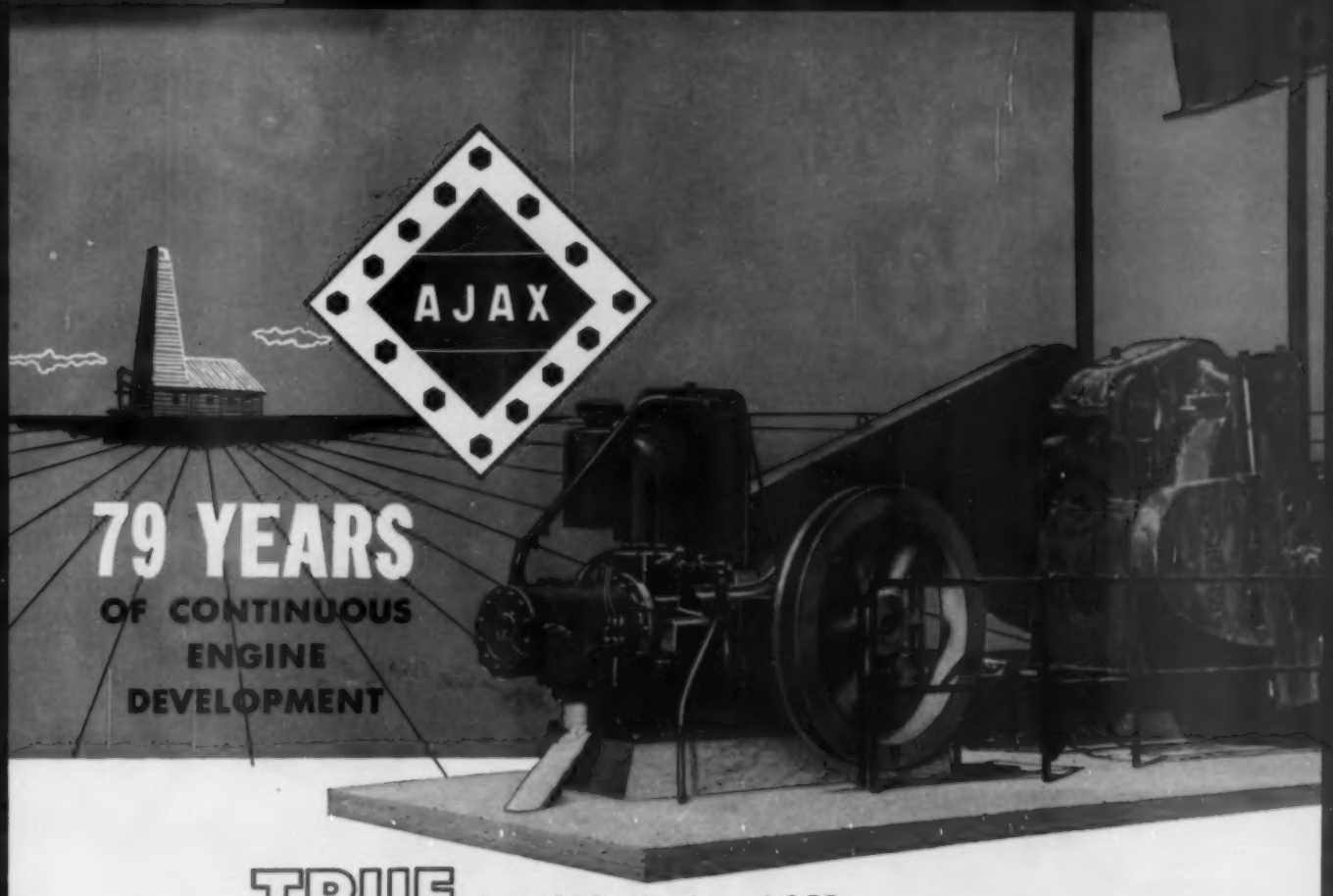
▸ **John W. Bell Jr.** . . . joined Texas Pacific Coal and Oil Company as district geophysicist for Southern Louisiana. He is a former geophysicist for Pan American Production Company.

▸ **Martin W. Schramm Jr.** . . . placed on temporary duty in Pittsburgh by Alex W. McCoy Associates, Inc., and **Thomas Herndon** . . . added to the Tulsa staff. Consultants **Orville A. Wise Jr.** and **Arthur C. Laura** . . . placed on temporary duty in the Columbus, Ohio, and Albany, New York areas respectively.

▸ **Sam N. DeWitt** . . . chosen new general manager of Voss Oil Company. He was former vice president and general manager of Seismogram Library Corporation and president of Century Corporation. Voss will be located in Newcastle, Wyoming.

Seagoing OIL RIG

For complete information, write:
The INGALLS Shipbuilding Corporation
Birmingham, Alabama



TRUE *since the beginning of OIL . . .*

A SINGLE CYLINDER DOES IT BEST

The cheapest and most dependable power in the oil producing business has always been provided by the horizontal, two cycle, crosshead type gas engine. This was true for the old-timers and it's true today. The only difference is in the engines!

Today's Ajax Gas Engine is a highly-engineered, precision product. Retaining all the essential simplicity of its great prototype, the Ajax you buy today is a product of the best design, the finest craftsmanship and the most suitable materials it is possible to obtain.

And Mr. Producer, if gas is obtainable, Ajax will deliver cheap power! *Ask your Supply Man for the particulars.*

Ajax MODERN GAS ENGINES

- SINGLE CYLINDER
- HORIZONTAL
- TWO CYCLE
- LOOP-SCAVENGED
- CROSSHEAD TYPE
- THERMO-SYPHON COOLING

for

ECONOMY
SIMPLICITY
LOW MAINTENANCE
CONTINUOUS DEPENDABILITY
LONG USEFUL LIFE

AJAX IRON WORKS

Builders of GAS AND OIL ENGINES, PRESSURE PUMPS, STEAM DRILLING ENGINES, INDUSTRIAL STEAM ENGINES

CORRY, PENNSYLVANIA

Oil Field Distributors: THE NATIONAL SUPPLY CO., PITTSBURGH, PA. R. B. MOORE SUPPLY CO., BOLIVAR, N.Y. • BETHLEHEM SUPPLY CO., TULSA, OKLAHOMA

Rector Casing Heads' Ring-of-Steel Seal

Like the famous rock—the welded seal in Rector's Casing Heads assures you PERMANENT COMPLETIONS unequaled in the oil industry. It will not burn out, deteriorate, flow under high pressure or temperature, or freeze and contract under low temperature, requires no maintenance, eliminates pressure equalization between strings.

This enduring permanence is made possible by Rector's specially designed Welding Ring and the application of an API ring gasket. On your next well specify Rector—the Cadillac of Casing Heads with the sealed-with-steel permanence of Gibraltar. More than 100,000 in service.

At authorized supply stores everywhere.

RECTOR WELL EQUIPMENT COMPANY INC

★ MAKING THE OIL INDUSTRY SAFER

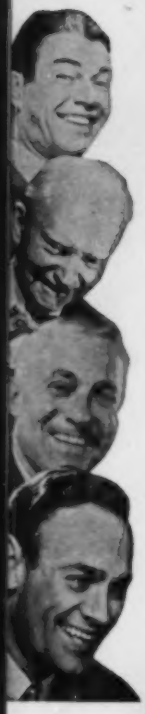
1100 NORTH COMMERCE ST. FORT WORTH, TEXAS

Houston Plant: 2215 Commerce St.

REPRESENTATIVES IN ALL ACTIVE FIELDS

PGAC

KEEPS OPERATORS SMILING!

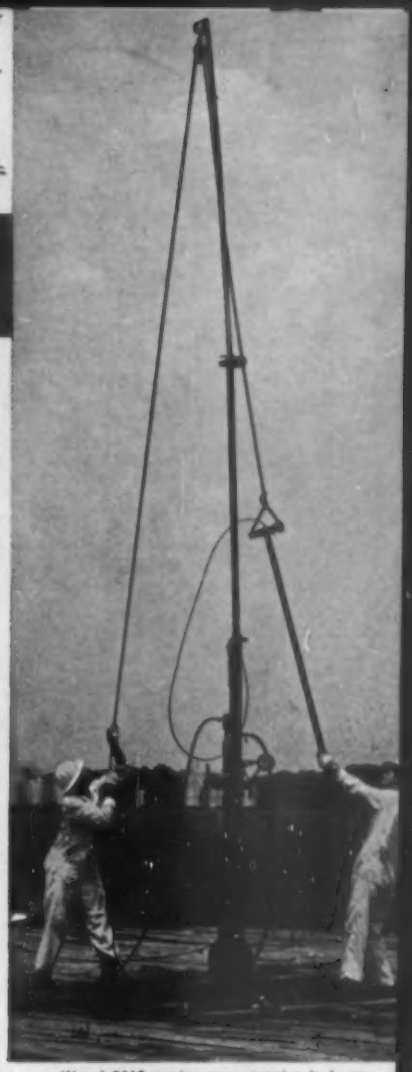


Now.. FIRST again

with a 1 11/16" SIMULTANEOUS RADIATION LOGGING INSTRUMENT FOR 2" TUBING COMPLETIONS

Remember...

PGAC—AND ONLY PGAC—GIVES YOU A SIMULTANEOUS GAMMA RAY and NEUTRON/NEUTRON LOG...ON A SINGLE TRIP IN THE HOLE!



PGAC-858

(Above) PGAC service crew preparing to lower new 1-11/16" Simultaneous Radiation Logging instrument through 2" tubing.

WHY USE 2 SEPARATE TOOLS REQUIRING 2 TRIPS IN THE HOLE?

- All of the superior logging standards of **calibration, stability** and **absence-of-drift**—for which operators have hailed PGAC's 3⅝" logging instrument for years—have been fully retained in this new 1 11/16" Simultaneous Radiation Logging Instrument now available for tubing completions.

- PGAC's Simultaneous Radiation Log is still the **only** Gamma Ray and Neutron/Neutron Log available. It utilizes a pure Neutron/Neutron to avoid the faulty phenomena of detrimental gamma rays inherent in all other "neutron" logs.

- **Moreover, PGAC *originated* and was the first company—*years before any other*—to deliver immediately in the field a simultaneously recorded radiation log.**

- Furthermore, PGAC has successfully logged and perforated the world's deepest (17,570 ft.) and hottest (349°F.) wells. Such know-how leads to PGAC's constantly improved instruments—tools without equal in accuracy, safety, operating speed and efficiency.

PGAC Simultaneous Radiation Log being recorded on instrument in field unit. Complete log is immediately delivered in field to operator.

PERFORATING GUNS ATLAS CORPORATION

Houston, Texas Telephone REpublic 4-1651

General Offices and Main Plant: 7730 Scott Street—Sales Office: Melrose Building

PGAC OIL FIELD SERVICES

CALL FOR PROMPT SERVICE—ALWAYS READY TO SERVE YOU

TEXAS: Abilene — Alice — Beaumont — Bowie — Colorado City — Corpus Christi — Dallas — Fort Worth — Gainesville Graham — Houston — Longview — Midland — Odessa — Pampa — Tyler — Victoria — Wichita Falls.
OKLAHOMA: Ardmore — Healdton — Oklahoma City — Pauls Valley — Pawhuska — Perry — Seminole — Tulsa.
LOUISIANA: Houma — Lafayette — Lake Charles — Shreveport. KANSAS: Great Bend — Liberal. NEW MEXICO: Hobbs.

AFFILIATE COMPANIES: CANADA—Perforating Guns of Canada, Ltd.: Edmonton, Alberta
GERMANY—Atlas Deutsch-Amerikanische Oilfelddienst G. m. b. H.: Kiel VENEZUELA—Servicios Tecnicos Atlas, C.A., Caracas

Wherever Strength,

Corrosion Resistance

and Long-Life are needed

you'll find

D+B

SUCKER

D+B QUIK-GRIP® ROD CLAMP

—for one-man installation

Eliminates "knuckle busting." Easy, quick opening is provided by a quarter turn of Tee-head permitting special forged bolt to slide through slot to remove clamp. Meets API specifications for pulling load.

D+B DUAL-PAC® STUFFING BOX

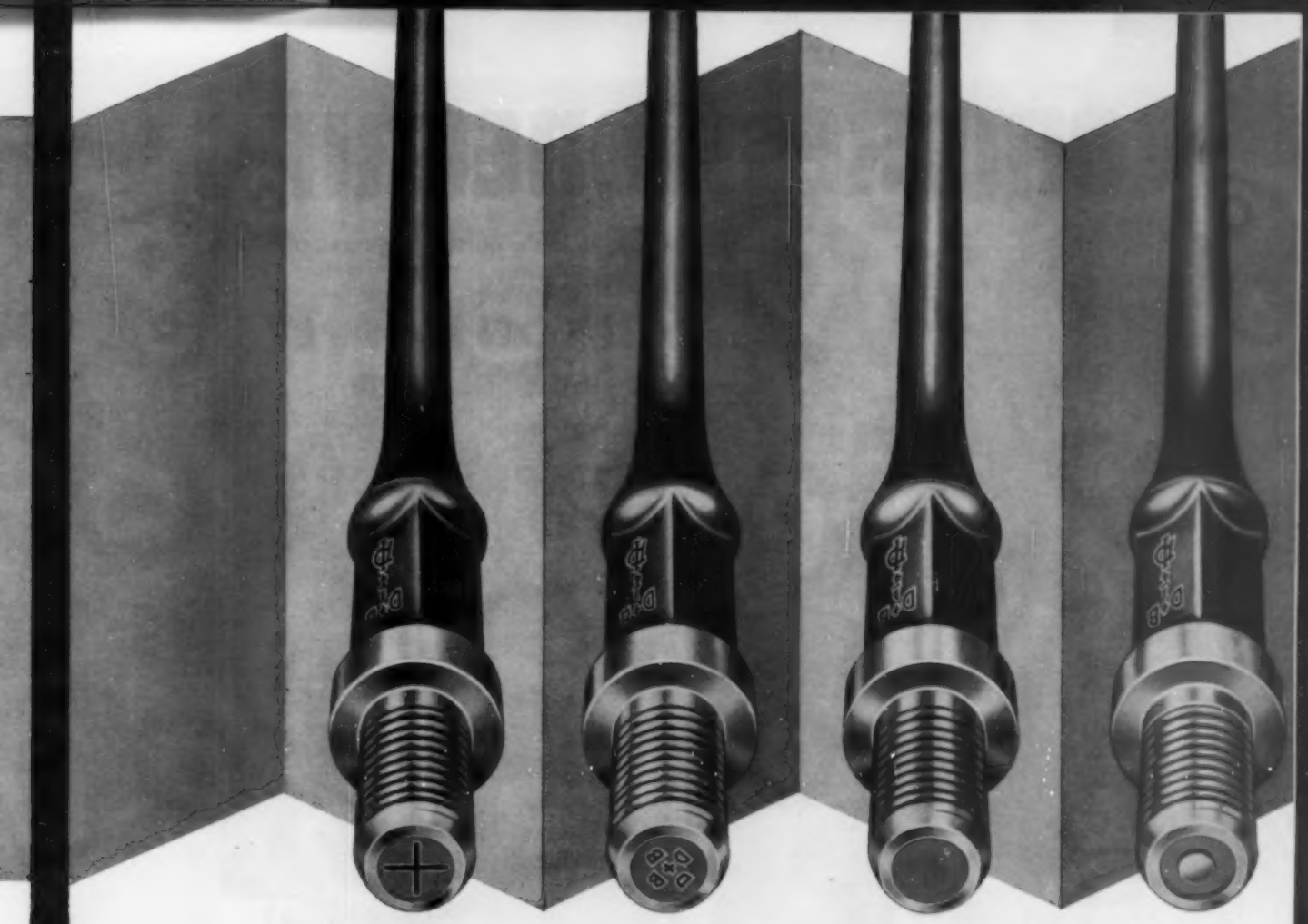
—a major time saver

Use of dual packing permits replacing the pressure seal packing easily without killing the well. Due to superior design, the higher the well pressure, the tighter the seal. Exceptionally wear resistant.

D+B API PONY RODS

—available in all diameters

in lengths of 2, 4, 6, 8, 10 and 12 feet and correspond to each sucker rod type. Made from metallurgically controlled steel, D+B API Pony Rods are full length normalized and drawn.



RODS

Made from special nickel-chromium, medium carbon manganese, nickel molybdenum or electric furnace high alloy steels, D+B Sucker Rods are favorites everywhere for heavy and medium pumping duty in severe, medium and ordinary corrosive wells.

Built by master craftsmen in the world's most modern sucker rod factory and backed by 50 years of know-how, D+B Sucker Rods combine strength, ductility and impact resistance. You get more for your money when you select them from complete stocks at the nearest CONTINENTAL or D+B store.

THE CONTINENTAL SUPPLY COMPANY

CONTINENTAL

Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: Dallas, Texas

Representatives in all principal oil fields of the world

D+B

• DEEP WELL PUMPS
• SUCKER RODS
• COUPLINGS

EMSCO

REG. U. S. PAT. OFF.

D+B DIVISION

EMSCO MANUFACTURING COMPANY

Garland, Tex. • LOS ANGELES, CALIF. • Houston, Tex.

General Sales Offices: Dallas, Texas

SR 603

*COMPRESSIONEERING

Has made possible the outstanding economical, satisfactory and continuous performance of:

WILSON SUPPLY

INGERSOLL-RAND

Packaged, Portable

COMPRESSORS

*The combination of proper engineering with skillful fabrication for every compressor installation.

Compressor Division, P. O. Drawer 19

BRANCH STORES

TEXAS: Alice, Corpus Christi, Victoria, McAllen, Bay City, Columbus, Barbers Hill, Liberty, Beaumont, Kilgore, Sherman, Odessa. LOUISIANA: Lake Charles, New Iberia, Houma, Harvey, Shreveport.

SALES OFFICES

DALLAS SHREVEPORT SAN ANTONIO
TULSA NEW ORLEANS LAKE CHARLES
CORPUS CHRISTI MIDLAND

WILSON SUPPLY CO

HOUSTON, TEXAS

Whatever your Completion

W-K-M
VALVES GIVE YOU BETTER CONTROL– MORE DEPENDABLE PERFORMANCE

Whether it's a single or dual completion, low or high pressure, oil or gas, W-K-M has the valve you need for maximum performance and dependability in your well control system.

These basic design and operating advantages are common to all W-K-M Valves:

- THROUGH-CONDUIT
- PARALLEL EXPANDING GATE
- PRESSURE SEAL BONNET
- LARGE PROTECTED SEATING AREA
- NO TURBULENCE
- MINIMUM PRESSURE DROP
- DOUBLE ROW THRUST BEARINGS
- SUPERFINISHED STEMS

Specify W-K-M Valves on your next Christmas tree and well control system.

FOR 1000 TO 5000 LB.

MODEL "L" VALVE

The industry's top ranking valve for Christmas trees, flow lines, etc. Sizes: 2" to 4". Working pressures: 1000 to 5000 lb. WOG.

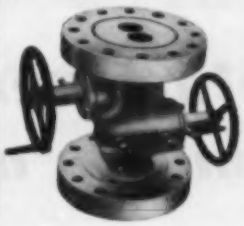
FOR 10,000 AND 15,000 LB.

BALANCED STEM VALVES

The heavy stem loads, set up by high pressure, are balanced out in this valve so that it opens or closes with one hand under full rated pressure. Sizes: 2" and 3½". Working pressures: 10,000 and 15,000 lb. WOG.

FOR DUAL COMPLETIONS

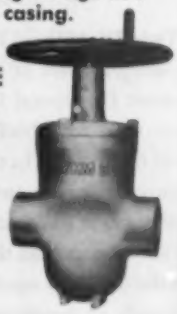
DUAL VALVE



Two valves in one body. Dual completion efficiency is greatly increased and assembly simplified. These valves are available in 2" and 2½" sizes for running two tubing strings in 7" or 8⅝" casing.

RECESSED BODY VALVE

The recessed body permits two parallel strings of tubing to be run in 7" or 8⅝" casing for dual completions when dual valve is not used. Sizes: 2" and 2½". Working pressures: 2000 to 5000 lb. WOG.



W-K-M MANUFACTURING COMPANY, INC.

A SUBSIDIARY OF acf INDUSTRIES INCORPORATED

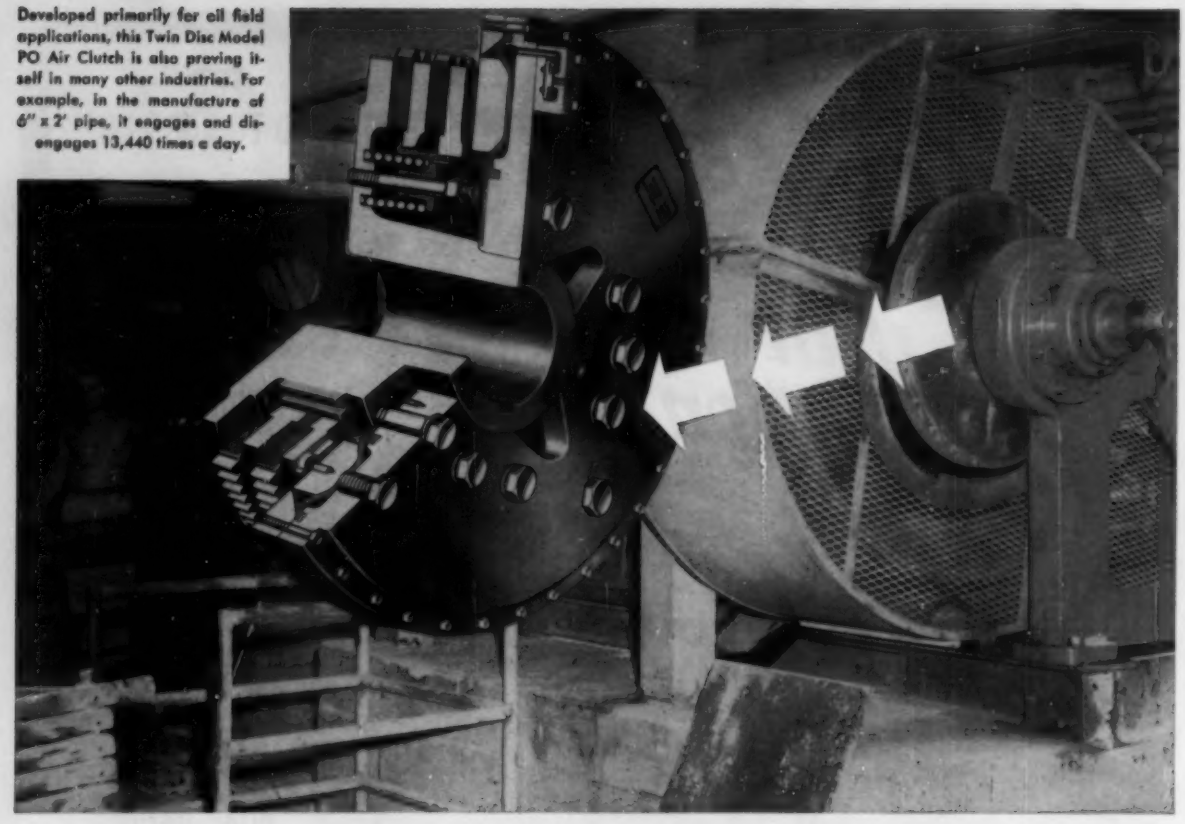
PLANT: MISSOURI CITY, TEXAS • MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

MANUFACTURERS OF

W-K-M	acf	KEY
THROUGH-CONDUIT GATE VALVES	LUBRICATED PLUG VALVES	RETURN BENDS AND FITTINGS

9610

Developed primarily for oil field applications, this Twin Disc Model PO Air Clutch is also proving itself in many other industries. For example, in the manufacture of 6" x 2' pipe, it engages and disengages 13,440 times a day.



13,440 clutch engagements and disengagements a day... every day

A Twin Disc Model PO Air Clutch is an *integral* part of a J. C. Steele Automatic Horizontal Extrusion Machine — used by a leading manufacturer of 6" x 2' pipe. In this operation, the clutch engages and disengages *13,440 times a day* — every day . . . many more times than the most severe use in the oil fields would require. *In ten months of continuous operation, no trouble whatsoever has been experienced and no maintenance has been required.*

Developed specifically for heavy-duty installations, the Twin Disc Model PO's advanced design features offer many outstanding advantages, including plenty of *reserve* capacity . . . more *compact control* of power transmission without complicated linkage . . . higher torque capacity (up to 126,600 lbs. ft.) . . . *faster, smoother operation* under all working conditions . . . *positive, quick release*—no seal drag—built-in pressure release valves . . . long, trouble-free operating life, with extra-large passages from cored back plate providing "air flow" cooling to the diaphragm insulator plate, springs and driving plates.

For more information, *more proof* on how the Twin Disc Model PO Air Clutch fits in to *your particular oil field applications,* call the nearest Factory Branch . . . Tulsa: 505 Enterprise Building, Sixth and Boston, Gibson 7-1578. Dallas: 1511 Turtle Creek Boulevard, Riverside 3014. Los Angeles: 2950 Leonis Boulevard, Logan 8-3309 . . . or write Twin Disc Clutch Company, Racine, Wisconsin. Request Bulletin 304.

TWIN DISC

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois

It's More Than A Sign — It's A *symbol!..*

Continental's "Green Triangle" was created as a sign of identification. But it has become much more than that. It is now a symbol of personnel integrity and product supremacy. It signifies Continental's modernization program to keep abreast of the oil industry's expanding needs. Continental's service paces itself with the growth of the world's oil fields and is excelled only by the search for new and better equipment.

Look to Continental for all your needs... all the time! You can always "Count on Continental."

▲*quality*

Quality products from outstanding manufacturers backed by Continental's 40-year reputation.

▲*service*

Time saving out-of-stock service from conveniently located stores saves you money.

CONTINENTAL

Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: DALLAS, TEXAS

Your Wickwire Rope distributor and our steel melter... always at your service

This steel melter—at Wickwire's open hearths where wire rope steel is made—is with your Wickwire Rope Distributor every time he makes a call.

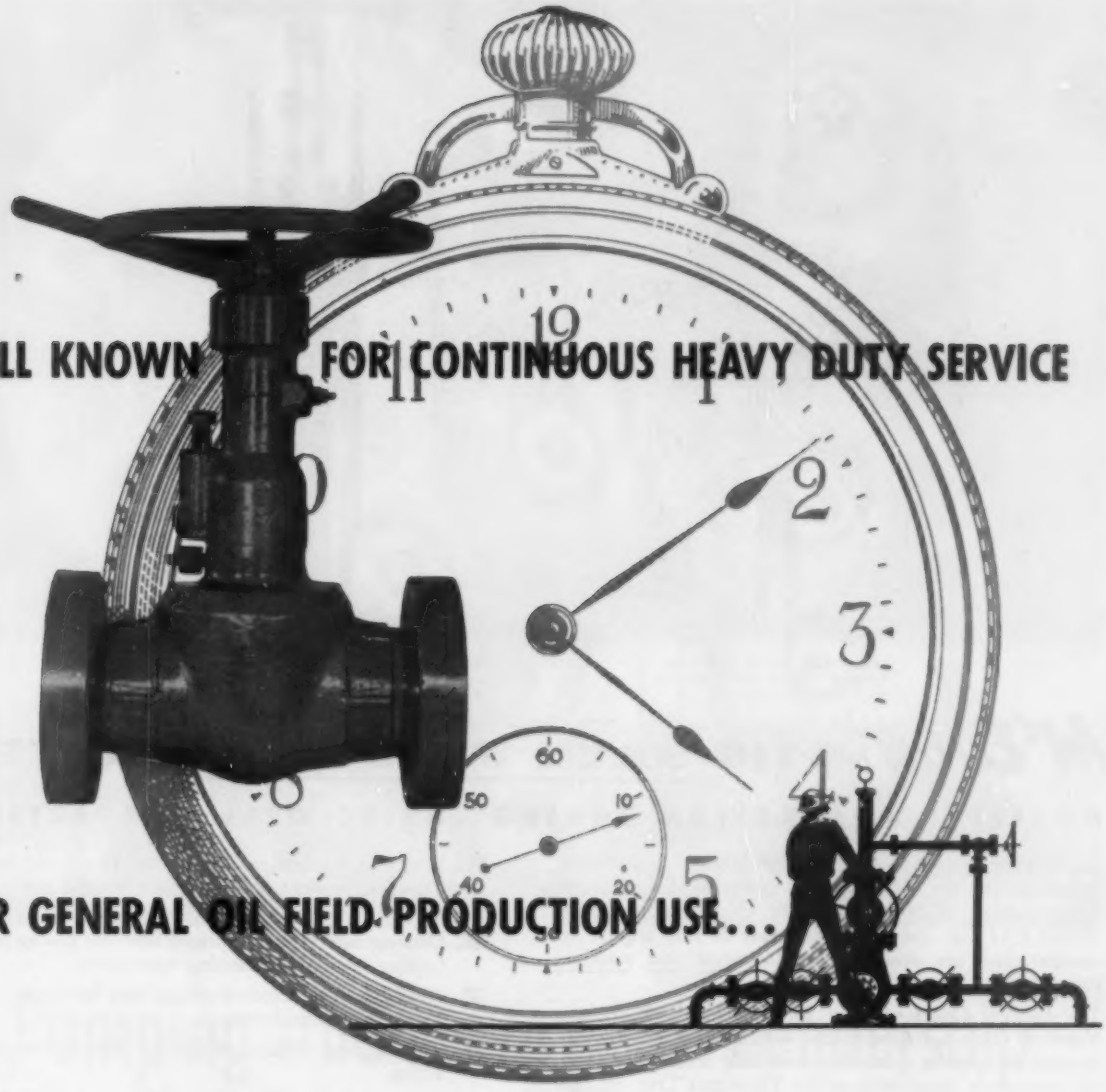
True, he's physically at the open hearth compounding steel with the sharp eye of an expert. But your Wickwire Distributor makes his call with the full assurance that the steel in Wickwire Rope has the right chemical content and grain size because it's always produced under rigidly controlled conditions by experts.

It's just one more reason why your Wickwire Rope Distributor knows he's got top-quality rope, slings and strand to sell ... and that these products will serve you well.

CF&I WICKWIRE ROPE A CF&I PRODUCT

4082

A PRODUCT OF THE COLORADO FUEL AND IRON CORPORATION



WELL KNOWN FOR CONTINUOUS HEAVY DUTY SERVICE

FOR GENERAL OIL FIELD PRODUCTION USE...

Applications: Meter runs, Christmas Trees, flow lines, separators, treaters, manifold systems, water flooding, gathering systems, salt water disposal, dual string tubing control and many others.

Features: Orbit Forged Steel Valves are specifically engineered and designed for general oil field production uses. Orbit has a well established reputation based on actual performance that provides positive seating without lubrication, easy operation, and long years of service with low cost maintenance.

Sizes: 1, 1½, 2, 2½, 3 & 4 inches, Flanged and Screw ends, Carbon Steel and Stainless Steel Trim. 500 lbs., Working Pressure to and including 5000 lbs., Working Pressure.

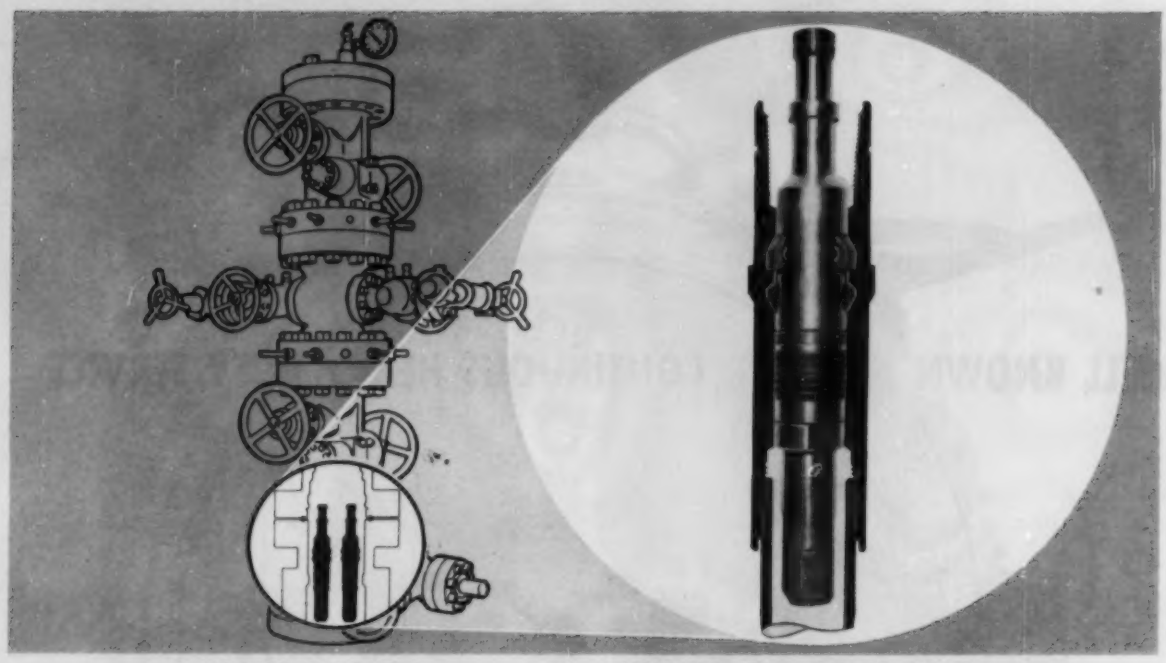
For greater service to the petroleum industry, Orbit has strategically located field warehouses and highly qualified field men. When you buy Orbit valves you also buy service at no extra cost.

ORBIT VALVE COMPANY

P. O. BOX 699 • TULSA 1, OKLAHOMA

ORBIT VALVES ®

HOUSTON, TEXAS 407 Velasco (Serving the Gulf Coast)
CASPER, WYOMING
247 West First Street (Serving the Rocky Mountain States and Canada)
ODESSA, TEXAS 402 West County Road (Serving West Texas)
EXPORT REPRESENTATIVE: 500 Fifth Ave., New York 36, N. Y. Ph. BRyant 9-2236
CANADIAN REPRESENTATIVE: 536 8th Ave. West, Calgary, Alberta, Canada Ph. 3-0437



Two McEvoy-Otis Back Pressure Valves as used in typical parallel string dual completion.

McEvoy-Otis Back Pressure Valve shown in Landing Collar. Note that Plug Locks and Seats in Machined and Honed Collar — *NOT* in Tubing.

McEvoy-OTIS BACK PRESSURE VALVES

POSITIVE PROTECTION DURING ENTIRE WELL COMPLETION

The McEvoy-Otis Method for safe high-pressure completions represents another McEvoy First in wellhead equipment. These tubing plugs are designed to withstand up to 15,000 P.S.I., are convenient and easy to run, require no rotation, and are available for all single and multiple completions.

The Landing Collar with the McEvoy-Otis Back Pressure Valve in place is landed in the Tubing Hanger. All subsequent completion operations, including removal of blow-out preventers, installation of the Christmas Tree, etc., are carried out with full pressure control. These McEvoy-Otis Back Pressure Valves may be removed under pressure and the well brought in. The Valves can be re-installed and/or removed under pressure at any time during the life of the well.

Two types of Back Pressure Valves are available. The "Standard" and the "Pump-Thru" types. The "Pump-Thru" type is used for displacing fluid through the valve under pressure, thus avoiding swabbing.

ADVANTAGES:

1. Tubing Bore and Annulus are under complete control; Tubing Bore is always fully protected by the Back Pressure Valve, and annulus is fully protected by McEvoy Tubing Hangers.
2. Locks into specially Machined (Selective) Recesses, does *NOT* depend upon threads or slips.
3. Seals on Honed smooth Surfaces....*NOT* on rough tubing wall.
4. Stainless steel Landing Collars with Massive Locking Recesses and Sealing Surfaces always provide Safe Latching and Sealing.
5. Wellhead Equipment (Christmas Tree) may be removed to re-work or re-complete without killing the well.
6. Drilling mud can be displaced from the tubing before landing, avoiding swabbing operations.
7. Available in all standard tubing sizes for Single, Dual, Triple, etc., completions.
8. The Landing Collars are the *full bore* of the tubing string.
9. Standard Tubing Size Master Valves are used — does *not* require oversize Master Valves and Tree.
10. The McEvoy-Otis Plugs and Landing Collars are Modified Type "S" (Otis) and are selective. They will not interfere with or accept regular Otis Plugs and other down-hole equipment.
11. McEvoy and Otis provide service, however, your own personnel can set, remove, and operate this simple equipment — tools are available for sale by or rental from McEvoy.

You gain Safety, Dependability, and Economy throughout the life of your wells by specifying and using McEvoy-Otis Back Pressure Valves. Thoroughly field proven in hundreds of high pressure wells. Let us show you.

McEvoy COMPANY

OIL WELL EQUIPMENT

TEXAS AND MILBY ST. • P. O. BOX 3127 • HOUSTON 1, TEXAS

McEvoy Company has an exclusive license from Otis Engineering Company to use and sell such locking and sealing devices, together with mating plugs, when incorporated in wellhead parts as are covered by their patents.

Pumping their way to Leadership

ALTEN PUMPING UNITS

Thousands of ALTEN Units—operating for years with low, low cost records —*Are Pumping Their Way to Leadership*. Put them to work for you!

Available in all sizes: small beam balanced, beam and crank balanced, or medium and large types with the ALTEN screw-type adjustable counter balance. You can be sure of peak performance with every model in each series.

Ask your independent supply store or write ALTEN for latest catalogue and engineering information.

✓ **A FULL LINE OF 47 MODELS AND TYPES**

✓ **WORLDWIDE DISTRIBUTION THROUGH SUPPLY STORES**

-ALTEN-
Foundry & Machine Works, Inc.
LANCASTER, OHIO

NEW Drilling and Producing Equipment

(1) Heavy-Duty Bearings. Link-Belt has expanded its line of mill bearings to include bearings for shafts up to 11-in. diam.

The self-aligning feature in mill bearings assures full-load carrying capacity,

even when the bearing is subjected to shaft deflections caused by heavy shock loads or support inaccuracies.

Link-Belt Company.

(2) Safety Coating for Slippery Surfaces. A friction-type, anti-slip coating for use on all types of metal surfaces exposed to oil or water has been announced by Lucey Export Corporation and Harper Chemical Company.

New coating is applied with a trowel to diamond plate, or flat plate, wood or concrete in thickness up to ¼ in. to provide safe, non-slip footing on even the oiliest surfaces encountered in and around drilling rigs, production units, refineries, and pumping stations.

It is particularly applicable on diamond plate walkways and steps or ladders between diesel engine compounds on drilling rigs, and in the working areas around drawworks, slush pumps and other machinery where workmen frequently have to step over transmission shafts in the course of their normal duties.

It is highly resistant to petroleum and all types of petroleum products, petrochemicals, greases, alkaline detergents, salt water, alcohol, acids, and nearly every corrosive agent met with in normal industrial operations

It won't chip, flake, crack, or peel — and it's gripping power actually improves with wear.

Lucey Export Corporation.

(3) Spring Reinforced Plastic Piping. Newage International introduces a versatile, flexible industrial tubing with the

trade name of Bardex.

Bardex is a special tensile-spring reinforced clear plastic piping, which is said to be uncrushable. Bardex is a highly flexible piping that will bend around a 5/16 in. spindle without distorting its internal bore.

Newage International, Inc.

(4) Two-Stage Pump. The Axelson two-stage sucker rod pump was designed for wells in which conventional pumping methods are inefficient due to high gas-oil ratio, gas locking, and in wells that must be producted from below a packer without gas separation.

It is a rod-type pump with a stationary barrel and is actually two pumps in tandem — a standard pump with a smaller one above it. Action of the two-stage pump has been aptly compared to that of a two-stage compressor.

Axelson Manufacturing Company, division of U. S. Industries, Inc.

(5) Hard Metal Application for Tool Joints. Reed Roller Bit is producing what it claims is a greatly improved hard metal

application that adds materially to the OD life of Reed tool joints.

The advanced hard metal application, known as Inarclad, welds the hard metal into the tool joint steel rather than binding the hard metal onto the surface of the tool joint.

Reed Roller Bit Company.

(6) Control of Two Separate Circuits. Two independent electrical circuits can be controlled simultaneously, it is claimed, with the Series 22000 dual-control Thermoswitch developed by Fenwal.

Basically, the thermostat consists of a liquid-filled sensing element, containing a sensitive bellows-and-push-rod assembly that actuates two precision miniature snap switches mounted in the head. Each switch may be connected to operate a separate electrical circuit.

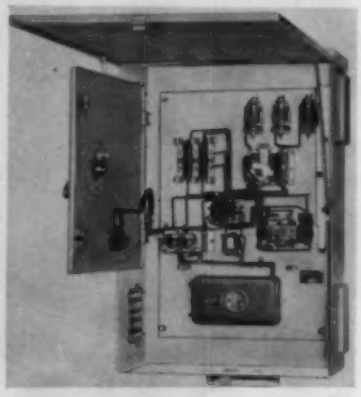
Fenwal Inc.

(7) Small Flow Control Valve. Annin announces production of a series of valves designed for working pressures to 6000 psi, which will provide industry research, and pilot plant engineers with an extremely high-speed and responsive small flow control valve.

Model 9460 features use of Annin's 600 Series differential area Domotor operator (patents applied for).

The Annin Company.

(8) Oil Well Pump Control. A new controller design bringing full automation to oil well pumping is announced by Cutler-



Hammer.

Cutler-Hammer Supertimer, heart of the new controller, programs the pumping operations in 15-min. periods and provides 73 accurately controlled restarting intervals in 2½-sec increments from zero seconds to as much time delay as 3 minu.

Cutler-Hammer, Inc.

(9) Insulating Handle-Bar Union. For many years, the oil fields have had the problem of insulating against electrolytic action in production lines.

Problem of keeping the current from traveling into adjoining pipe sections is claimed to be solved by the Clayton Mark Insulating Handle-Bar Union.

Insulating gaskets are of nylon fabric, impregnated with Hycar rubber, which remains pliable after long service. Designed and constructed to provide positive insulation on pipe lines up to 3000 lb, C.W.P. Insulating Handle-Bar Unions have cadmium plated ends and a Parkerized nut.

Clayton Mark & Company.

(10) Flexible Coupling with Brake-Drum Flange. A flexible coupling incorporating a brake-drum flange on the outer diameter is now available from Lovejoy.

This feature provides a compact drive arrangement and is particularly useful where shaft length or distance between two units is at a premium. In effect, the brake drum entails no more space than that required by the flexible coupling.

Brake drum coupling is available in eight standard sizes, with horsepower ratings from 2 to 40 at 1750 rpm. Maximum bores of the hub body range from 1 in. to 2½ in.

Lovejoy Flexible Coupling Company.

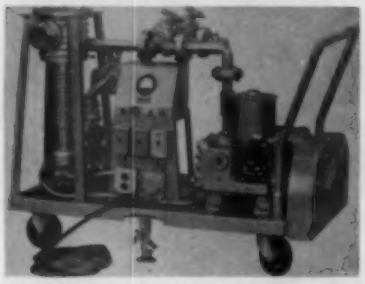
(11) Dynamic Force Gages. A series of force gages is available from Endevco for the accurate measurement of dynamic forces in any system or structure.

New methods of dynamic testing are made possible by the use of this device, which provides a voltage output proportional to dynamic force.

Endevco Models 2103 and 2104 force gages provide large, self-generated outputs of approximately 5 full scale. They are available in full scale ranges of 100, 500, 1000, and 5000 lb. Unloaded, natural frequency of the units ranges from 20 kc to 50 kc, providing the flat frequency response to at least 5000 cps.

Endevco Corporation.

(12) Portable High-Vacuum Pumping Unit. For general laboratory work, pilot plant operations, and small scale production applications, Kinney Manufacturing Division of New York Air Brake has produced a portable, high-vacuum pumping system.



Designed to attain absolute pressures as low as 10^{-6} mm Hg, this mobile system employs a fractionating 4-in. diffusion pump, connected to a 15-cfm two-stage roughing and backing mechanical vacuum pump.

Kinney Division, The New York Air Brake Company.

(13) Turbo-Charged Diesels. Hercules Motors offers three series of turbo-charged diesels.

The TCD-501 is a 6-cyl model, has a 4½-in. bore x 5¼-in. stroke and produces 178 hp at 2000 rpm. The TCD-895 is also a 6-cyl engine but with a 5⅜-in. bore x 6-in. stroke and develops 320 hp at 2000 rpm. The TCD-1468 is an 8-cyl V-type model and has a 6¼-in. bore x 6-in. stroke while developing 520 hp at 2000 rpm.

Hercules Motors Corporation.

(14) New Carrotless Jet Gun.. A revolutionary jet perforating method which is said to result in "all hole—no carrot," has meen developed in Midland, Texas.

Recent laboratory tests made of a new jet perforating charge resultd in a penetration of 3.7 in., with an entrance diameter of ⅜-in., and left the perforation free of the customary plug — or "carrot."

This completely clean hole is made possible by eliminating the formation of a "carrot" through internal diffusion of the charge debris inside the gun body.

The new jet perforating method known as the Rocket J-II, was perfected by the development and research division of Western.

Western now has Rocket J-II units in the field, which are operating from various company stations throughout the Permian Basin, Kansas, and Oklahoma.

The Western Company.

(15) Automation Aide. Assembly-line automation appears to have moved a step closer to actuality with the development by Minneapolis-Honeywell of a new switch, operating on the "proximity" principle, to keep tabs on moving metal parts.

Electronic research engineers at Minneapolis-Honeywell's Doelcam division, who designed it say the new switch works like a "magnetic detective" to locate objects containing iron on assembly lines, in liquids and even the moving parts of automatic machine tools. The switch has no moving parts. Any break in the sequence is immediately detected and generally shuts down the line.

Doelcam Division Minneapolis-Honeywell Regulator Company.

(16) Silicone Defoamer. A faster-acting, more stable silicone defoamer, Antifoam B, has been developed by Dow Corning.

Useful in a wide variety of applications, it is generally effective at concentrations in the range of 3 to 30 parts per million. Instantly dispersible in aqueous systems, Antifoam B may be added "as is" without stirring or agitation.

Dow Corning Corporation.

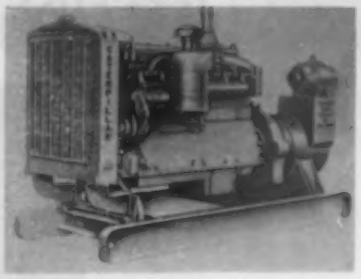
(17) Conversion Kit. Conversion kits are now available for converting Caterpillar D386 and D364 Diesel Engines into gas-burning, spark-ignition engines, according to an announcement by Caterpillar Tractor.

These new conversion kits can be installed only on counter-clockwise rotation engines not equipped with turbo-chargers or Roots blowers. Parts included in the kits are essentially the same as those used in the D397 (Series D) and D375 (Series D) Spark Ignition Engines.

Primary advantages of the converted engines include lower operating costs, especially in areas where natural gas or other suitable fuel is available at low cost, and increased horsepower.

Caterpillar Tractor Company.

(19) Diesel Electric Set. A 100-kw, self-regulated diesel electric set has been added to the expanding line of Caterpillar-built power generating equipment.



Known as the Cat D342 Electric Set, the unit uses one of the highly compact new Caterpillar self-regulated generators to make available the principal advantages of previous self-regulated and externally-regulated generators in one package. In order to assure maximum efficiency, the new generator has been designed and built specifically to match the Cat D342 Diesel Engine.

Caterpillar Tractor Company.

(20) Electronic Data Logger. The Kybernetes Logger, announced by the company, is said to present an entirely new engineering concept to the logging field.

Advanced techniques developed for the computer industries are incorporated. Accuracy is conservatively guaranteed 0.2 per cent for all inputs, including non-linear types, over extended periods of operation. Reliability is claimed because of the complete absence of mechanical operations except for the normal complement of high-quality sealed relays, which have a life expectancy in the decades.

The Kybernetes Corporation.

(18) Geology Trailer for Oil Field Use. A special geology unit for field use has been completed by Melody Home Manufacturing.

This oil field unit was manufactured for a West Texas oil company for use in the field. It is equipped with specially designed laboratory desk and filing systems, so that analysis in the field can be made quickly and efficiently. The new unit provides ample working and bunk areas for a crew of two men.

Melody Home Manufacturing Company.

NEW Literature

For more information on items describea here in brief, use the handy reply card and circle the corresponding numbers

(21) Multi-Stage Flowmeters. Fischer & Porter has published an illustrated catalog covering the company's line of multi-stage, variable-area Flowrator meters.

Instruments are claimed to provide guaranteed indication within 0.5 per cent of true flow rate over ranges of from 5 to 100,000 lb per hour.

Fischer & Porter Company.

(22) Direct-Acting Solenoid Valves. A single-page bulletin describing and illustrating additions to its line of bronze and stainless steel solenoid valves has been issued by J. D. Gould.

Included in the new models are Type AD bronze valves from ½ in. to 1 in.; Type KD stainless steel valves in sizes from ½ in. to 1 in., and Type GD stainless steel valve in ⅜ in. size.

J. D. Gould Company.

(23) Rig-Up for Export. An eight-page, pictorially illustrated folder showing the steps in assembly of one of the world's largest rigs for export is now available from Joe Stine.

Unique features of mud system, pump, drawworks, control units, and transport method are shown.

Joe Stine, Inc.

(24) Oil Field Metering and Oil and Gas Separation. Rolo Manufacturing has issued an oil well separating and metering equipment catalog.

This two-color, illustrated, 24-page catalog also illustrates and describes automatic samplers and all accessories for well separating and metering units.

Rolo Manufacturing Company.

(25) Film Report of Pretesting. Byron Jackson Pumps announces an 18-min, full-color sound film entitled "Model Test Pit for 400 MGD Pumps."

This film — actually an engineering report — shows how the engineers at Byron Jackson thoroughly pretested the BJ pump installation for the giant Tidewater refinery in Delaware. Extensive animation is used in the film to demonstrate variations in pumping situations.

Byron Jackson Pumps, Inc.

(26) Vacuum and Pressure Gages. A four-page, illustrated brochure on its line of vacuum and pressure gages has been released by Hastings-Raydist.

Featured is the new Hastings Model LV-1 Vacuum Gage, which is designed to give highest accuracy in 0-100 micron range, but is also available in range of 0-1000 microns Hg.

Hastings-Raydist, Inc.

(27) Wellhead Equipment. National Supply has issued a bulletin covering complete line of wellhead equipment.

In addition to product description, the bulletin includes an index to detailed product literature on the various components of National Wellhead Equipment.

The National Supply Company.

(28) Chlorinated Rubber Paints. Hercules Powder has released two publications on new developments in Parlon-based finishes affecting corrosion problems.

One is a reprint article on chlorinated rubber paints. The other is a revised edition of a company brochure, which provides documentary evidence of the performance of Parlon finishes in corrosive enviornments of all types.

Hercules Powder Company, Inc.

(29) Freeze-Drying Lab Equipment. "Freeze-Drying Equipment for Laboratories" is the subject of a 36-page catalog published by Arthur S. LaPine.

Catalog includes descriptions of freeze-drying units, vacuum gages and pumps, bath coolers, refrigerated centrifuges, and related laboratory and small-scale production equipment.

Arthur S. LaPine & Company.

(30) Storage Tanks. A catalog and data book on the patented "Tubeseal" System for floating-roof storage tanks has been published by Hammond Iron Works.

Illustrated catalog describes the design and construction of the improved Hammond Tubeseal — the only floating-roof seal that completely eliminates every space between seal and product, according to the manufacturer.

Hammond Iron Works.

(31) Sheave for Multiple V-Drives. The complete line of Maurey Ful-Grip Q-D Sheaves, standard Multi-V Sheaves, and special made-to-order sheaves is presented in an illustrated catalog now available from Maurey Manufacturing.

Catalog gives practical information on the handling of sheaves as well as dimensions and descriptions.

Maurey Manufacturing Company.

(32) Aluminum Alloys and Mill Products. A comprehensive reference handbook on aluminum has been made available to industry by Alcoa.

The 176-page book presents data on aluminum alloys and mill products in an easy-to-read tabular form, with little text.

Aluminum Company of America.

(33) Engineering Manual. Amplex Division of Chrysler announces the release of an entirely new engineering manual containing complete details about Oilite products.

The 52-page illustrated manual contains a special 12-page insert, which lists over 1000 standard Oilite sleeve, flange and thrust bearings, cored, solid bar, and plate stock.

Amplex Division, Chrysler Corporation.

(34) Enclosed Lineshaft Turbine Pump. Layne & Bowler Pump offers a bulletin in full color showing detail cutaway sections of all components of its Verti-Line turbine pump, enclosed lineshaft type.

Bulletin opens to 45 in. with full-length pump illustration, large enough so the smallest part can be plainly seen.

Layne & Bowler Pump Company.

(35) Hydraulic Hose Selector. A rubber-covered hydraulic hose selector is being offered free to users of Hydraulic Control Hose or to interested companies by the Republic Rubber Division of Lee Rubber & Tire.

The revised selector contains latest S.A.E. and industry specifications on hydraulic hose.

Republic Rubber Division, Lee Rubber & Tire Corporation.

(36) Diesel Engines. Alco Products has announced publication of a 14-page bulletin on the company's new "family" of diesel engines — the 251 series — available in ratings from 550 to 2400 hp.

The two-color bulletin illustrates the engine series, which includes the 6-cyl, in-line model and the 12 and 16-cyl, V-type engines.

Alco Products, Inc.

(37) Heavy-Duty Torque Converters. Heavy-duty, single-stage hydraulic torque converters for transmission of 100 to 1000 hp to drilling rig operations, are described in a bulletin issued by National Supply.

Bulletin gives features and specifications of 17 sizes and capacities of National Torque Converters for exact matching with engines in this power range.

The National Supply Company.

(38) Oil and Gas Well Stimulation. Chemical Process has published a 20-page catalog of its oil and gas well stimulation services.

Included are descriptive data and other information on acidizing and fracturing services, "Permeter" survey services, and auxiliary services such as emulsion and water block-removal treatments.

Chemical Process Company.

(39) Unusual Surveying Problems. "Tips from the Surveyor's Notebook" — a collection of short articles on unusual surveying problems and their solutions — has been published by W. & L. E. Gurley.

The 20-page "Notebook" contains the articles, case histories, and field tips that have created most comment and have proved most helpful to engineers and surveyors during the six years the "Notebook" has been published. The new volume contains selected pages from Series One and Two.

W. & L. E. Gurley.

(40) Rigid Plastic Pipe Installation. An eight-page, illustrated bulletin on its line of High-Impact Rigid Koroseal pipe, fittings, and valves has been published by B. F. Goodrich.

Back page of the brochure is devoted to a chart listing common chemicals handled by Rigid Koroseal pipe, fittings, and valves.

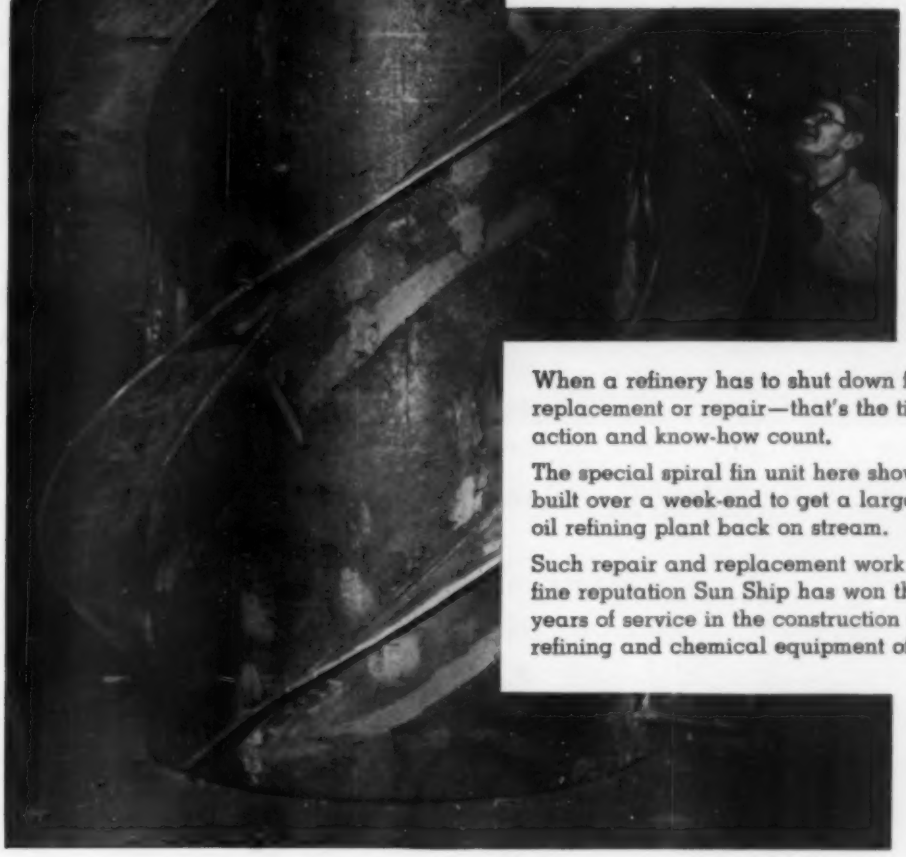
The B. F. Goodrich Company.

(109) Forged Steel Fittings. A 28-page illustrated catalog on forged steel pipe fittings is now available from W-S Fittings Division of H. K. Porter.

Bulletin contains complete dimensional, engineering and application data on the division's forged screw-end and socket-welding fittings for high-pressure service. Catalog features a reorganization of data into simplified charts.

W-S Fittings Division, H. K. Porter Company, Inc.

FAST REPLACEMENT



When a refinery has to shut down for a replacement or repair—that's the time when action and know-how count.

The special spiral fin unit here shown had to be built over a week-end to get a large oil refining plant back on stream.

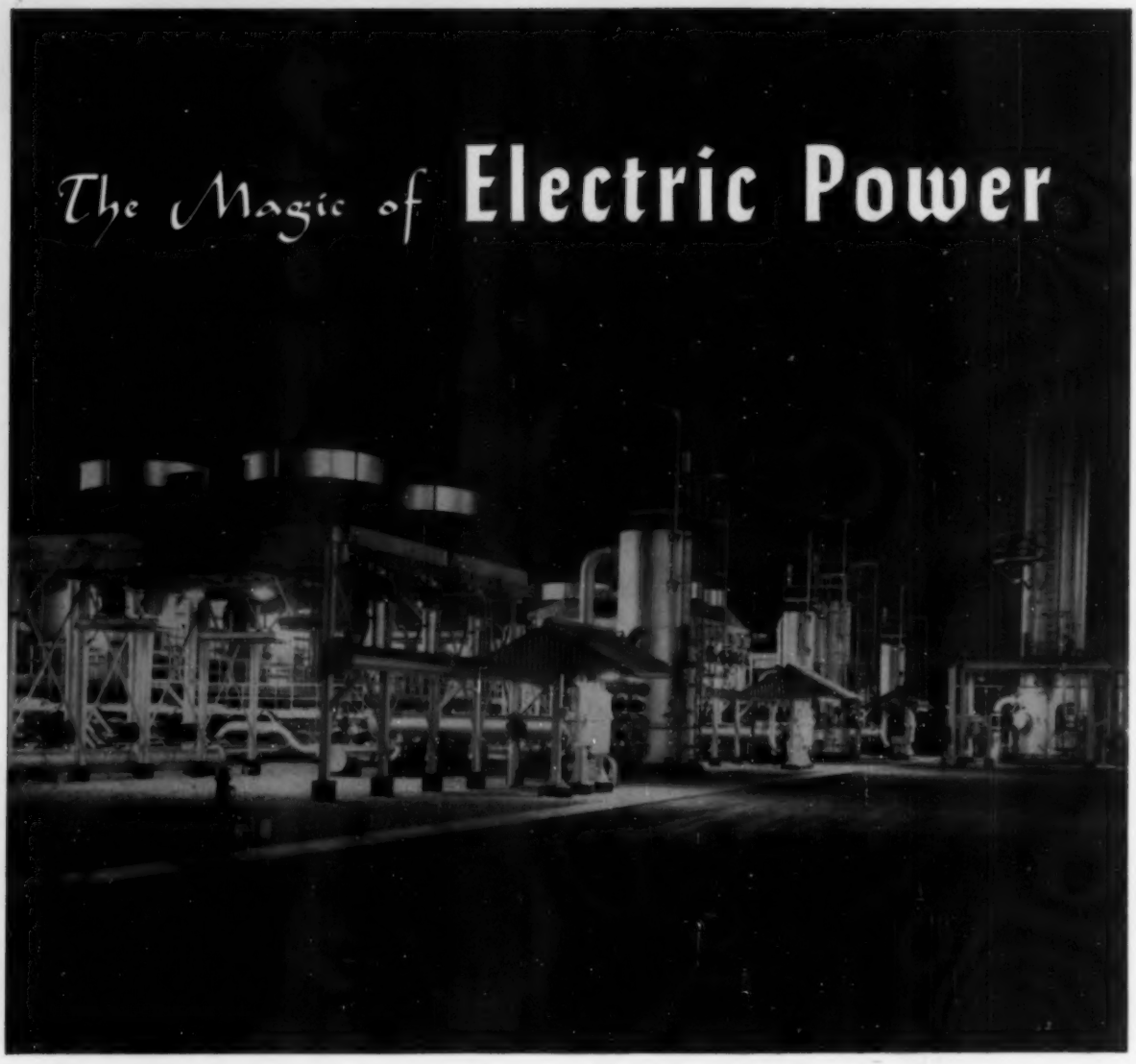
Such repair and replacement work has added to the fine reputation Sun Ship has won through years of service in the construction of oil refining and chemical equipment of every kind.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) CHESTER, PA.

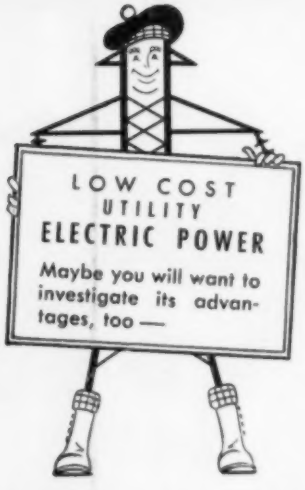
The Magic of Electric Power



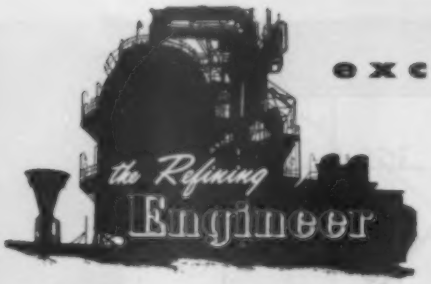
Service... Dependable Service

Next to a captivating sunset nothing has such a magical appearance as a giant refinery flooded by the grandeur of electric light on a pitch dark night.

Spectators view it with unceasing awe — Businessmen view it as a well-lighted, efficiently powered investment. Over 72 per cent of this nation's refineries utilize dependable purchased Electric Power. More cost conscious men are specifying it every year.



WRITE PETROLEUM ELECTRIC POWER ASSOCIATION, P. O. BOX 2771, DALLAS, TEXAS, OR CALL THE SALES ENGINEER OF YOUR LOCAL UTILITY ELECTRIC POWER COMPANY — NOW



exclusive

Covered separators reduce hydrocarbon evaporation; automatic pH control minimizes corrosion.

Taming Wild Waste Water!

Gordon W. Brown, and James E. Sublett
Union Oil Company of California

UNION OIL COMPANY of California has installed at its Los Angeles Refinery new waste water facilities designed to process 50,000 gpm of waste water. An unusual feature of this installation is that they include covered primary separators which essentially eliminate evaporation losses and air pollution.

The Los Angeles Refinery has a capacity of 110,000 bbl per day of crude oil and is situated on 450 acres of land adjacent to the Los Angeles Harbor. Wastes originate from various refinery processes including fractionation, cracking, reforming, isomerization, alkylation, chemical treating of oil stocks, sulfur and ammonium sulfate manufacture; from operation of utility and service facilities and from maintenance and repair activities. All process water from these facilities and a major portion of the surface drainage flows through the waste water processing facilities.

The flow of waste water has increased considerably with refinery expansion during the past 25 years. In order to reduce the possibility of air or water pollution from refinery waste waters, and also to conserve potential oil losses, a decision was made in 1952 to rebuild the existing facilities.

At that time, the waste water processing facilities included two separator systems operating in parallel. Each system consisted of a primary separator in series with a large baffled basin. This system was effecting a satisfactory removal of oil during normal flows of water. However, during certain turnaround periods and rain storms, the primary separators were not satisfactory. Considerable amounts of oil were carried out to the secondary separator increasing the work load on the operating personnel. In addition, from an air pollution control standpoint, they had also become unsatisfactory. This was

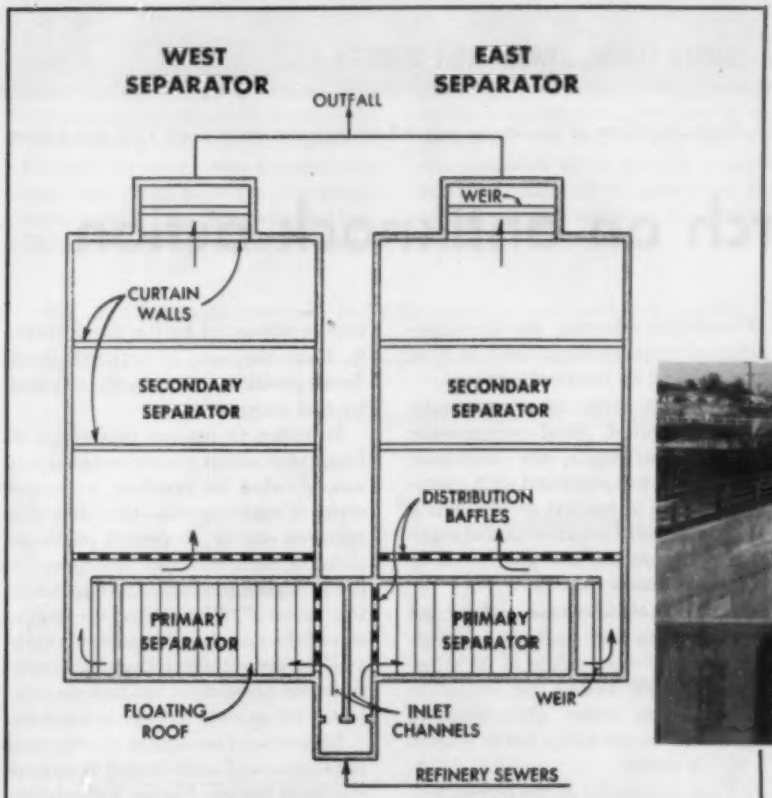


FIG. 1. Schematic plan for waste water facilities.

FIG. 2. Primary separation inlet distribution baffle.

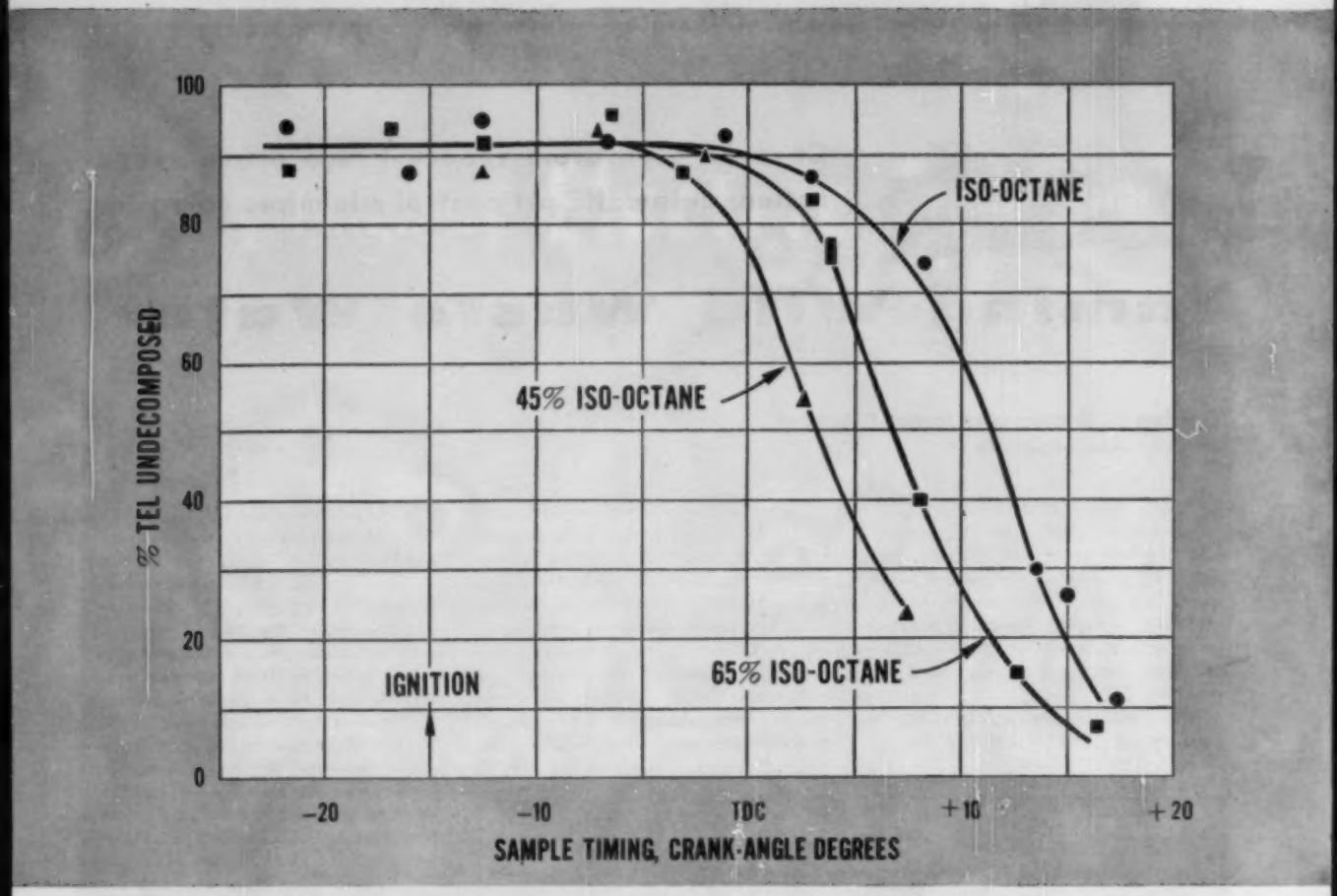


Fig. 1. TEL decomposition in fired engine. Fuels: mixtures of iso-octane and n-heptane containing 6 ml TEL per gallon.

New research on antiknock action

by ***ELLIS B. RIFKIN***
Ethyl Corporation, Detroit, Mich.

Although tetraethyllead is widely used as an antiknock agent, some fundamentals of its action are still not completely understood. Since a full understanding of the mechanism of its action could presumably lead to increased effectiveness of utilization—the Ethyl Corporation conducts a continuing basic research program on antiknocks.

Many theories concerning the mechanism by which tetraethyllead acts as an antiknock in the internal combustion engine involve either the process by which tetraethyllead decomposes or the products resulting from such decomposition.

This report describes the studies of variables affecting the decomposition of tetraethyllead both in fired engines and in motored engines.

In a first series of experiments, a spark-ignited, fixed-compression ratio, L-head engine was employed. This engine was equipped with a sampling valve of special design which permits repetitive extraction of small samples from the end-gas region of the combustion chamber.

Mixtures of iso-octane and normal heptane were used as fuels, and end-gas samples were taken at 5° intervals from 25° before top center to 20° after top center. The results of these studies are indicated in Figure 1 which shows:

1. That essentially all the tetraethyllead is decomposed before the mixture is consumed by the flame front.

2. That the rate of tetraethyllead decomposition is markedly affected by fuel composition.

In order to resolve this effect of fuel composition more completely, it was decided to conduct a second series of experiments—this time in a motored engine, to permit measurement of temperatures. A single-cylinder engine was again used, but in this series of experiments, the engine was of the variable-compression ratio type to permit variation of temperature and pressure of the fuel-air mixture over as wide a range as possible.

Mixtures of iso-octane and normal heptane as well as di-isobutylene were the fuels tested. Figure 2 illustrates the effect of fuel composition on tet-

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

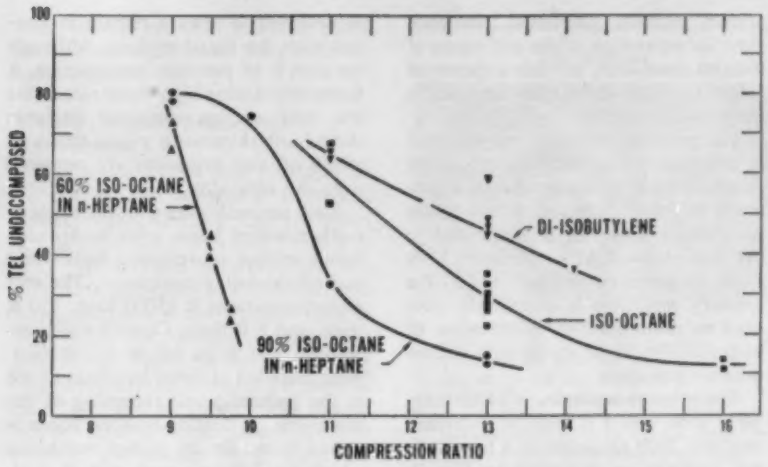


Fig. 2. Effect of fuel on TEL decomposition in a motored engine.

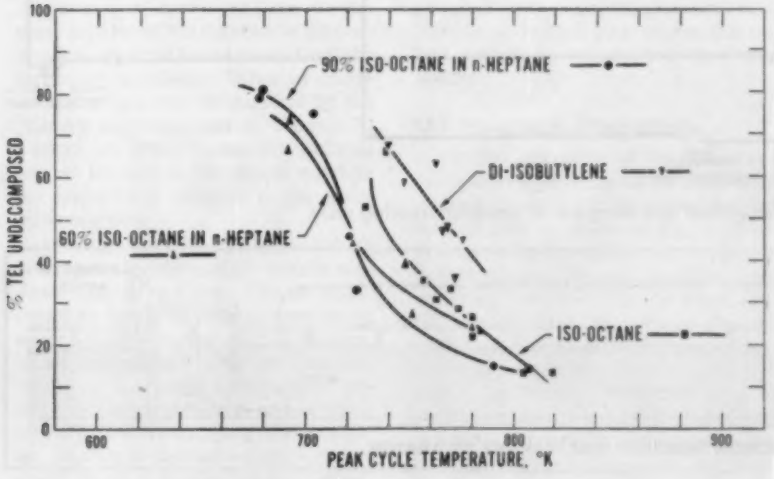
raethyllead decomposition in the motored engine—somewhat comparable data to that shown in Figure 1 for the fired-engine studies.

Again, an apparent correlation was obtained between fuel composition and rate of tetraethyllead decomposition—with the more rapid rates being associated with fuels of higher octane number.

To gain still greater insight into this relationship, technicians calculated peak cycle temperatures and the tetraethyllead decomposition data were examined against this variable. The results of this work are shown in Figure 3. It can be seen immediately that most of the variation due to fuel composition has been eliminated. This leads to the conclusion that temperature may be the one basic variable governing the decomposition of tetraethyllead—and that fuel composition has only an indirect influence so far as it affects the peak temperature of the charge in the cylinder. A mathematical analysis taking into account the variation in temperature of the charge throughout the cycle and comparison of those data with tetraethyllead decomposition data confirm this conclusion.

This account of one typical research project in the Ethyl Laboratories is designed to give you in the petroleum industry a glimpse into the vast body of continuing research being carried out to guarantee the maximum effectiveness of "Ethyl" Antiknock Compound.

Fig. 3. TEL decomposition in four fuels related to peak cycle temperature.



What Ethyl Research offers you

Ethyl Research is in the unusual position of being able to serve both the petroleum and automotive industries.

In that capacity, we have contributed much in the field of fundamental as well as applied research. Today at our laboratories in Detroit we are conducting studies on the nature of combustion . . . the cause of preignition . . . and the mechanism of deposit accumulation.

Searching for answers to these "basic" problems has led us to develop many new instruments and new techniques. The information which we have developed from our research efforts is being constantly circulated throughout both the automotive and petroleum industries to help the different companies with their research.

If you desire any information concerning fuel-engine problems, just contact your Ethyl Laboratory Technical Representative.

ETHYL CORPORATION
New York 17, N. Y.

Research Laboratories:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

because of changing standards in the Los Angeles Basin rather than any fundamental change in refinery operations.

To alleviate these problems, the Union Oil Company designed and installed facilities to meet the following objectives:

1. Increased efficiency of waste water processing.
2. Substantial reduction of air pollution from hydrocarbon evaporation.
3. Automatic effluent pH control.
4. Continuous treatment of emulsions.

Design of System

The new waste water facilities are comprised of two identical parallel systems which have a design capacity of 50,000 gal per minute of water. Each system consists of a primary and secondary separator in series as shown in Fig. 1, Schematic Plan. Essentially all the oil and emulsion separates out in the primary separator. The secondary separators provide additional residence time for separation of the last traces of difficult emulsions, provide a factor of safety for high water rates, and act as fire water reservoirs.

The primary separator was designed in accordance with the basic principles recommended by the American Petroleum Institute.[1] There are two main differences, however, as compared to the conventional API separator: 1) a flight scraper is not utilized, and 2) the primary separator is completely covered to minimize the evaporation of hydrocarbons to the atmosphere and reduce air pollution.

The primary separator is 140 ft long, 40 ft wide, and 8 ft deep. It is divided into two 20-ft channels by a longitudinal partition as indicated in Fig. 2. Each separator is covered with eleven rectangular-shaped pontoon roof sections. Each roof section is 12 ft long, 40 ft wide, and 2 ft thick. The roof is so designed to always remain in contact with the liquid surface. Although the roof is of pontoon construction, it floats only during high water rates. The last roof section supports rotatable slotted oil-skimming pipes through which oil and emulsions are removed from the separator.

Each secondary separator consists of earthen-walled basin with inlet distribution section, oil-retention baffles, and and oil-skimming equipment. The secondary separator is 350 ft long, 150 ft wide, and 8 ft deep. Curtain walls, extending 2 ft 6 in. below the surface, were installed at three locations to aid in the gathering and skimming of the emulsions. A floating wooden boom is pulled manually to gather emulsions which rise between each curtain wall. Emulsions are removed with the aid of a floating self-adjusting skimmer.

All recovered oils and emulsions are transferred to tankage by steam reciprocating pumps. Mild steel was used in all phases of construction; i.e., roofs, pipe

(1) American Petroleum Institute, *Disposal of Refinery Wastes*, Volume I: Waste Water Containing Oil, Fifth Edition.

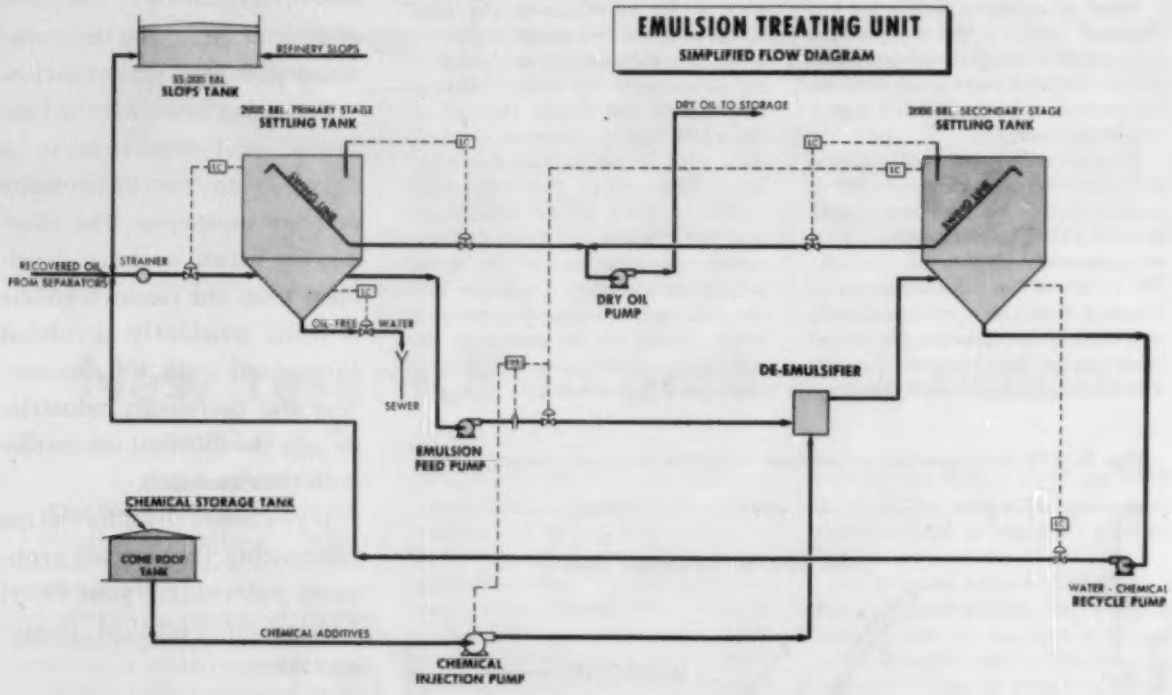


FIG. 3. Simplified flow diagram of emulsion treating unit.

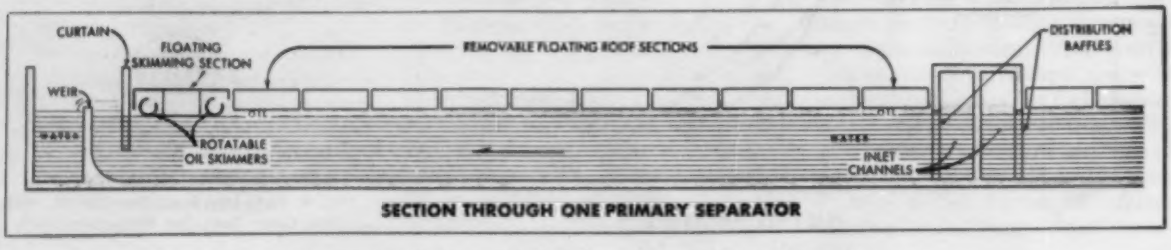


FIG. 4. Vertical cross-section through one primary separator.

lines, valves, etc. No corrosion problems of any significance have been encountered.

Waste Water Separator Operations

The waste waters join upstream of the two parallel systems in a covered concrete collection box. This collection box is 46 ft long, 4 ft wide, and 8 ft deep. Water from the collection box then flows by gravity to the two parallel primary separator distribution boxes. It then enters the primary separator settling section where the residence time is approximately 90 minutes for normal flow. Oil and emulsions are continuously skimmed from these sections through the slotted pipe skimmers which extend the width of the separator. More than 99 per cent of the incoming oil and emulsions, approximately 700 bbl per day, separate from the water in the primary separator. The recovered oil and emulsions are pumped to a settling tank. Tests indicate that there are no measurable hydrocarbon losses to the atmosphere from the covered primary separators.

Water containing 30-35 parts per million oil, flows over the primary separator weir into the secondary separator distribution box and then into the settling section. Residence time in the secondary separator is approximately 14 hours for normal flow. This allows ample time for the carried-over emulsions to become disengaged from the water. Emulsions are skimmed off once a day and pumped to a settling tank. Water containing only dissolved oils then flows over the outfall weir to the West Basin of the Los Angeles Harbor.

The normal water flow through the waste water facilities is approximately 8000 gpm. During periods of rain storms, rates of 30,000 to 35,000 gpm have been experienced with only slight increases in oil carryover from the primary separator. No increase in oil content has occurred in the water from the secondary separators. Water in excess of that which may be handled by the primary separators can be diverted to a storm pit. When the waste water rate returns to normal, the excess water in the storm pit is returned to the sewer collection box.

Although the refinery handles sulfide bearing crudes, the outfall water is normally free of sulfides. This is maintained by handling those process waste water streams high in sulfide content, in an independent collection system. The water is released to the sewer only after extensive stripping action. During periods when stripping units are upset, dilution of residual waters with salt water from a separte system effiectively reduces sulfide concentrations.

The Authors

James E. Sublett, Jr. is a process engineer with Union Oil Company of California at their Los Angeles Refinery. He joined the Company in 1951. Graduated from the University of Southern California with a BE in Chemical Engineering. Prior to his current assignment, he spent three years as an engineer in the bulk operations department where one of his responsibilities was the supervision of the operations of the refinery waste water handling facilities.

Gordon Brown graduated from the University of Southern California with a BE in Chemical Engineering in 1951. He joined Union Oil Company the same year. He has worked in laboratory, process engineering, and at present is operating engineer in the asphalt refined oil department.

In addition, some reduction in sulfide content occurs through aeration and oxidation as the water goes over weirs and through the secondary separators.

The pH of the waste water entering the separators is controlled between 6.5 and 7.5. This is necessary to control the effluent pH and to prevent excessive corrosion. The pH of the influent water is measured by pumping a sample through a glass electrode cell. Whenever the pH is outside the permissible operating range either spent acid or caustic is automatically added at the main sewer collection box. To prevent fouling of the glass electrode cell from oil, a 10-foot section of 8-inch pipe was installed upstream of the glass cell. This horizontal baffled pipe allows the oil and emulsions to separate from the water.

Oil Recovery Operation

Normal operation of the oil-recovery system is to pump all the recovered oil and emulsions to the primary stage settling tank as shown in Fig. 3. Here the recovered oils split into three phases due to gravity: dry oil, emulsion, and water and sediment. The top phase, dry oil, contains two per cent or less of water and sediment and is pumped out automatically to storage as it accumulates. The middle phase, emulsion, is recovered continuously and pumped through a de-emulsification unit,[2] to the secondary stage settling tank for final separation. The bottom phase, water and sediment, is returned to the primary separator. Unique in the design of this oil-recovery unit is the application of an interface detection instrument which permits the automatic recovery of dry oil as it accumulates in the settling tanks.

The oil-recovery system has a capacity to treat 2000 bbl per day of emulsions. During periods when the emulsion recovery rate is higher than the oil-recovery system can handle, the excess is diverted to a 35,000 bbl floating roof storage tank. In addition, this tank receives slops from other sources in the refinery including tank bottom sludge, ship ballast containing oil, wet crude bottoms, etc. Clear water is withdrawn periodically from the bottom of the tank. Oil which has risen to the top of the tank is periodically pumped to storage for refractionation. During periods of low recovery rates from the waste water facilities the emulsion from the storage tank is put through the de-emulsification unit. Several types of chemical-emulsion breakers are continuously mixed into the fresh emulsion which effectively reduces the emulsion to dry oil and water sediment. To date, this process has treated over 750,000 bbl of all types of emulsions on a once-through basis.

(2) This de-emulsification process is licensed by the Union Oil Company of California.

Maintenance

It has been necessary to shut down each separator system once a year for clean-out of the primary separator. Over a period of time, dirt and coke settle in the primary separator distribution box and settling chamber. Large accumulations of this material effectively reduce the residence time of the influent water and thereby increase secondary separator operations which are more laborious. Repairs to equipment have all been minor. ★ ★ ★

Unfired Pressure Vessel Code Discontinued

The code of standards used by the American petroleum industry for over 20 years to build and maintain pressurized production and storage facilities will be discontinued on December 31, 1956. Known to engineers as the "API-ASME Code for Unfired Pressures Vessels for Petroleurm Liquids and Gases," it was formulated and published jointly by the American Petroleum Institute and The American Society of Mechanical Engineers.

The move was announced recently with the publication of a joint declaration by the two groups signed by their respective presidents—Frank M. Porter for the API and Joseph W. Barker for the ASME.

Solves Power Transmission Problem, Reduces Cost and Maintenance.

Overall view of the two aerial cooler units in which hydraulic drives are employed.

P 773.53.

HYDRAULIC DRIVE for Aerial Cooler Fans

D. E. Bumgardner
Plant Superintendent, Chicago Corp.

THE Chicago Corporation operates a natural gasoline plant at Carthage, Texas, for the purpose of processing natural gas from the Carthage field and extracting the marketable liquid hydrocarbons contained therein. It was determined during the summer of 1954 that it would be necessary to expand the existing wet gas compression facilities at the plant, in order to deliver gas from some of the low pressure reservoirs to the established plant absorption pressure of 1050 psig.

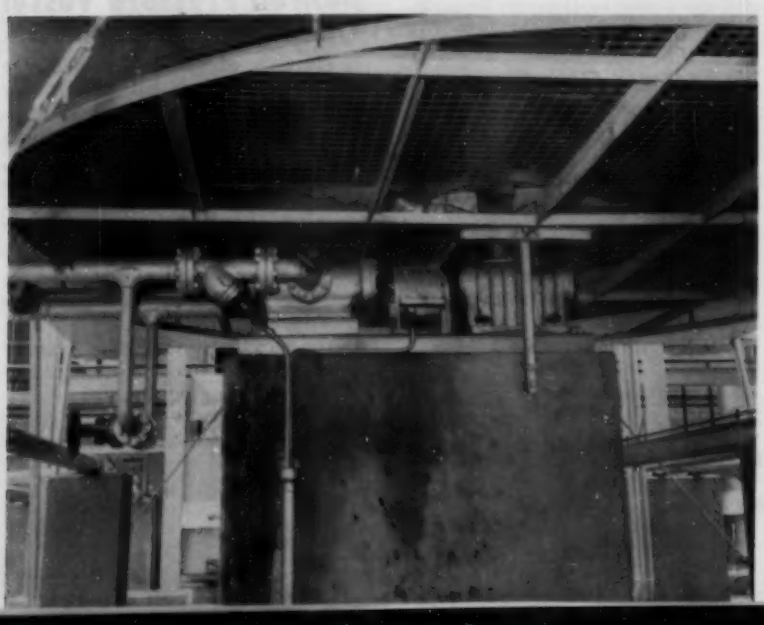
One of the decisions to be faced in regard to this expansion, involved the selection of a cooling system which would take care of the increased compression and engine heat load.

Before addition, the compression facilities consisted of two 1320 hp gas engines which compressed 500 psi wet gas to 1050 psi. This was a single stage operation. Final gas cooling and jacket water cooling were accomplished by coils in a two-cell induced draft cooling tower. Cooling tower circulating pumps, draft fans, and jacket water pumps were electrically driven by purchased power. A gas engine-driven generator set was provided as emergency stand by in the event of electrical power failure. Although only one of the existing compressors was operated at that time, it was determined that the original cooling facilities would handle the heat requirements for a two engine, single-stage operation.

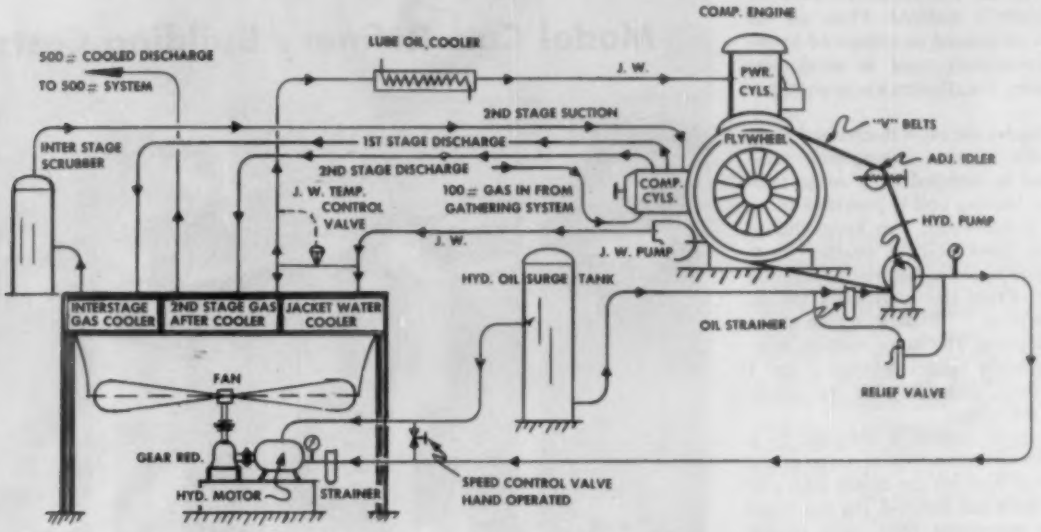
It was decided that the new addition would involve extending the building and setting two more 1320 hp gas compressors. These engines would take 100 psi gas from the field and compress it in two stages into the existing 500 psi suction header. At this point, the low pressure gas would be comingled with the incoming 500 psi stream from the field and then compressed to 1050 psi by the original installation.

Several of the more conventional routes to the solution of the problem of added heat load were noted. One approach involved the construction of another cooling tower (or the enlargement of the existing one) thereby duplicating and/or enlarging upon the old cooling system. The disadvantages of this method were thought to be as follows:

1. Large construction and invest-



One hydraulic motor and gear reducer, with fan speed control valve at left center.



Diagrammatic layout of the hydraulic drive system

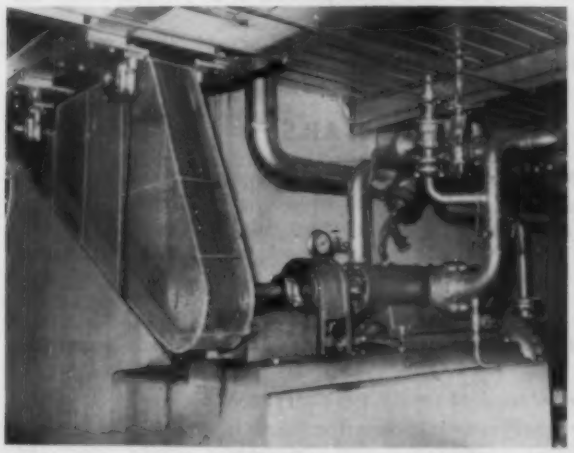
ment costs for new or extended tower, coils, and piping.

2. Inconvenient utilization of space.
3. Inherent problems of water-type cooling:
   a. Algae
   b. Scale
   c. Corrosion
   d. Wood deterioration
   e. Chemical treatment costs
4. Requirement of purchase of additional electrical power.
5. Larger investment for emergency stand-by power.

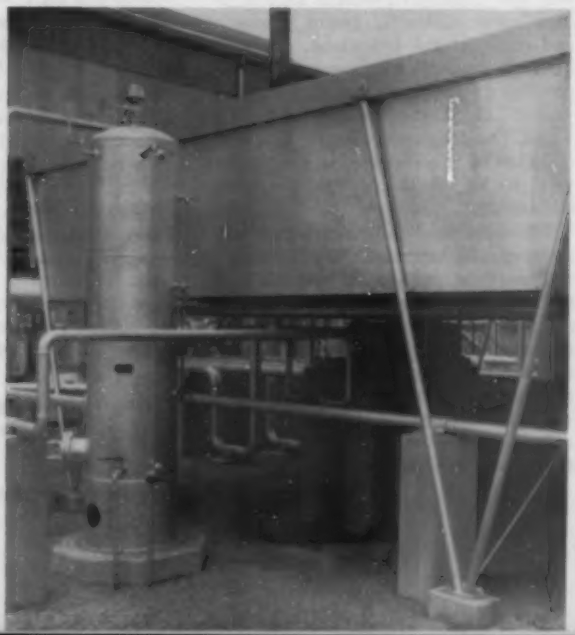
As an alternate to additional cooling tower investments and attendant operational problems, the use of aerial-type coolers was considered. It was also decided that some means of cooler fan drive, other than electrical, be investigated so that no additional electric power would be required. The idea of using a fraction of the engine horsepower for this purpose seemed logical. One of the first considerations was the use of a line shaft from the engine as a mechanical drive. Space limitations demanded that a line shaft of considerable length would be required. The next consideration was the idea of using hydraulic power transmission for fan drive. This seemed an efficient and flexible system, and one which could be expected to require little maintenance. As a result of these conclusions, the hydraulic drive system for aerial cooler fan drive was selected and installed in the new addition.

The hydraulic and cooling systems for each of the low pressure compressors are identical, separate, and self-contained units. The system is described as follows:

Approximately 56 bhp are taken from the flywheel through a direct "V" belt drive to a gear-type hydraulic pump at 36 bhp. Normal flywheel speed is 300 rpm, which imparts a speed of 1290 rpm to the pump. At this speed, the pump is capable of putting up 425 psig; pumping 164 gpm of 200 SUS oil to a gear-type hydraulic motor at the fan. Under these conditions, the fan motor rotates at 1410 rpm. Through gear reduction, this speed is reduced to 242 rpm at the four-bladed 16 foot fan. The fan blades have a



The hydraulic pump and V-belt drive, set in the basement.



Hydraulic fluid surge tank alongside the aerial cooler.

pitch of 14.8 deg, and under these conditions an air movement of 34.4 air horsepower is realized. Thus, on the basis of air moved as compared to engine horsepower used to attain the movement, the efficiency is near 60 per cent.

The hydraulic oil is discharged from the motor at near atmospheric pressure and is directed to a surge tank where a heating coil is provided using engine jacket water. This keeps the oil warm in times of cold weather when the engine is down; thereby facilitating start-up. From the surge tank the oil flows through a 100 mesh screen at the pump suction. The pump suction pressure normally ranges between 3 and 5 psi vacuum, depending on the condition of the screen.

Fan speed control is obtained by a manually operated bypass valve at the fan motor between the motor inlet and outlet. With this method, the fan speed can be controlled from zero to the maximum of 242 rpm. A relief valve set at 450 psi is installed on the pump between discharge and suction as protection in case of excessive hydraulic pressure build-up.

With this system, each unit meets the following cooling requirements:

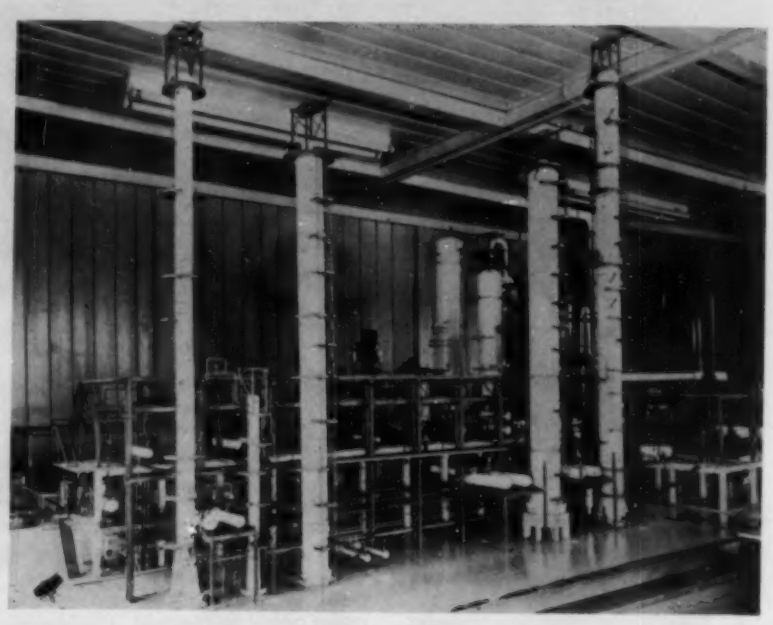
1. Interstage gas cooling between first and second stage.
2. Second stage gas aftercooling.
3. Jacket water cooling.
4. Lube oil cooling (by use of cooled jacket water exchanging heat from the lube oil in a separate shell and tube exchanger).

Jacket water temperature is also controlled by a bypass valve between the inlet and outlet of the jacket water coil. This valve is operated by a temperature recorder-controller.

Thus far, one operational difficulty has been experienced with this system. At times of extreme ambient temperature, jacket water temperature control was lost. This was found to be due to insufficient hydraulic pump pressure and resultant low fan speed. A check of the hydraulic oil viscosity at the experienced oil temperature of 160 F revealed 125 SUS when using SAE 30 wt oil. The design viscosity for this unit is 200 SUS. It is expected that by using SAE 40 wt oil, this difficulty will be eliminated.

Maintenance has been insignificant as was to be expected. The 100 mesh screen at the pump inlet was cleaned frequently during the first few months of operation. This is rarely necessary at the present time. Two of the self-aligning pillow bearings on the "V" belt idler pulleys have been replaced. V-belt tension is checked and adjusted as required. One year of operation with these units was completed in March of 1956. ★ ★ ★

Model Cuts Refinery Building Costs



A scale model of a second catalytic cracking plant is now being used as a three dimensional blue print by Shell Installations and Plants at Pernis (Rotterdam) Refinery.

Built of wood, plastic and copper to a scale of one in 50, the model enabled technologists to study the plant and the layout of the pipelines before building began, thus solving many problems in good time and avoiding alterations during construction. Later it was also used for planning the erection of the shear legs when large components were being hoisted into position.

The model is build in three parts: the catalytic cracker itself with fractionating column, the distillation plant in which the feed is prepared, and the gas treater. These are mounted on separate tables which can be placed together for studying the complete plant.

Despite its high cost (about $19,000), the model has proved an economic proposition, and has made possible many savings, particularly in drawing costs. Other savings were in the cost of pipework, painting, etc., for the plant: by studying the model contractors were able to make more accurate estimates of the work involved and their tenders were, on average, 10 per cent to 20 per cent lower. The model is also being used to train operating personnel.

So successful has this model been that models of new plants for other Shell refineries are now being made which will cost about $5000.

PLANT DETAILS

Total number of drawings	about	4000
Number of piles	about	1900
Pipes, diameter 2 in. and over	about	2000 tons (about 25 miles)
Steel structures	about	2500 tons plus 1200 tons in buildings
Installed capacity	about	25,000 hp or 18,430 kw

(equal to 1/5 of the maximum available capacity of the electric power station in The Hague)

Quantity of cooling water required about 3.8 million gallons per hour

(equal to ¾ of the hourly consumption in The Hague in 1955)

EXCLUSIVE

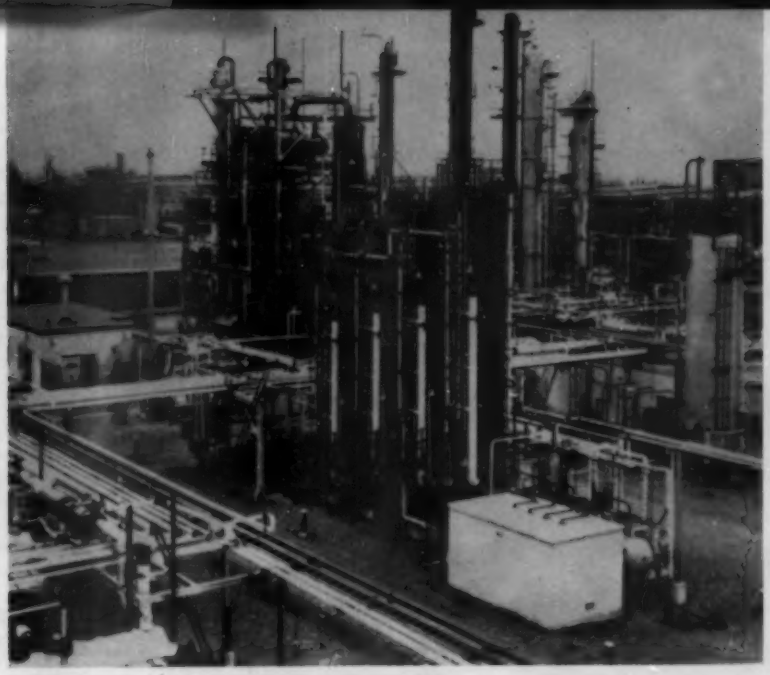


FIG. 1. The oxidation section of B. A.-Shawinigan's phenol-actone plant.

Petrochemicals Unlimited from Ethane, Propane and Butanes

Oxygenated Petrochemicals

PART V

Section 2: Millions of new products can be made by the oxidation of hydrocarbons to form ketones, acids, aldehydes, alcohols

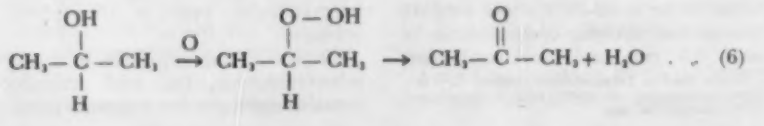
Peter W. Sherwood
Chemical Engineer

Acetone As By-Product of Hydrogen Peroxide

MUCH interest attaches to a new method for the manufacture of hydrogen peroxide in which acetone is obtained as by-product[10]. The process is believed to be the basis for a plant now under construction at Shell Chemical Company's Norco, Louisiana, plant.

The raw material for this synthesis is isopropanol:

Molecular oxygen serves as oxidizing agent in this reaction which is carried out in the liquid phase. For reasons of practical conversion rate, the lower temperature limit is 90 C. Yield considerations set the upper limit at approximately 140 C. (Typical range is 100-105 C). In this range, of course, elevated operating pressure is called for. To keep the pressure within practical bounds, concentrated (80-95 per cent) oxygen is preferred to oxygen.



$$CH_3-\underset{\displaystyle H}{\overset{\displaystyle OH}{\underset{|}{\overset{|}{C}}}}-CH_3 \xrightarrow{O} CH_3-\underset{\displaystyle H}{\overset{\displaystyle O-OH}{\underset{|}{\overset{|}{C}}}}-CH_3 \longrightarrow CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3 + H_2O \quad (6)$$

It is essential that the system be free of substances that can promote the decomposition of peroxides, such as heavy metals (e.g. copper, iron, nickel, etc.). A lengthy incubation period for the reaction can be avoided by adding a small amount of peroxide (e.g. hydrogen peroxide itself) to the feed. Although a very small amount of such an initiator is effective, the preferred initial concentration of hydrogen peroxide is of the order of 1 per cent, based on the alcohol weight.

Continuous operation of the process is feasible and is, indeed, preferable. Once the reaction has been started, no further initiator peroxide need be added to the feed. At steady state, high concentrations of hydrogen peroxide may be attained in the product. But, for reasons of operating safety, such concentration is held to a maximum of 25 per cent. Yield of hydrogen peroxide is near 90 per cent and acetone recovery is 90-95 per cent of theory.

The product is distilled. Isopropyl alcohol and acetone are taken overhead, but enough water must be added to the system to hold hydrogen peroxide concentration in the bottoms below 50 per cent. For the distillation, use is made of a peroxide stabilizer, such as sodium metastannate and acetanilide).

Production of Acids and Anhydrides

While acids and anhydrides derived from $C^2 - C^4$ hydrocarbons have a great diversity of uses, the number of major outlets is quite limited.

Acetic acid, together with its anhydride, is by far the most important of aliphatic acids, with the following 1953 production volume in the United States:

Acetic acid	467,000,000 lb
Acetic anhydride	806,000,000 lb

Principal uses are in the fields of plastics and synthetic fibers production. It has been estimated that 60 per cent of acetic acid output is consumed in the production of cellulose acetate flakes; 30 per cent goes to the production of acetate esters (q.v.), and the balance is taken up by applications in textile processing and by the production of metallic acetates, rubber chemicals, etc.

. 2. Acetic-anhydride-from-acetone plant; a view behind the control panel.
Courtesy: Courtaulds, Ltd., London.

Acetic anhydride depends almost completely on the market for cellulose acetate which accounts for some 95 per cent of total consumption. The production of one pound cellulose acetate consumes 1.7 lb acetic anhydride and 2.5 lb glacial (100 per cent) acetic acid, but yields 3.5-3.6 lb dilute acetic acid as recoverable by-product.

Other uses for acetic anhydride include the production of acetyl salicylic acid (aspirin), acetanilide, the plasticizers triacetic and acetyl ricinoleates, as well as diverse minor derivatives.

The higher homologues of acetic acid and anhydride find only relatively limited application. Here, we must mention **butyric acid,** with an annual estimated production of 1,200,000 lb per year, used for the production of cellulose acetate butyrate plastics, esters for perfumery purposes, etc. **Propionic** acid is not today commercially significant, but recent tests have shown reliable horbicidal characteristics in its chlorinated derivatives.

The following discussion will deal with the methods employed in the production of acetic acid, acetic anhydride, and their C_4-homologues from petrochemical sources.

Production of Lower Aliphatic Acids

It is possible to obtain aliphatic acids by the direct oxidation of the corresponding alcohols. This route has, however, two drawbacks; namely, the formation of a dilute aqueous acid which must be subjected to costly concentration, and difficulties of temperature control in the highly exothermic system.

The preferred route from alcohol to acid calls therefore for two-step operation: Alcohol → aldehyde → acid.*

Production of aldehydes from aliphatic alcohols has been considered already. In the presence of manganese salts (usually of the desired acid), molecular oxygen will oxidize aldehyde to the corresponding acid in very high yield. By a variation in the catalyst, a mixture of acid and its anhydride is obtained.

Of outstanding importance is the manufacture of acetic acid by liquid-phase oxidation of acetaldehyde:

$$CH_3CHO + O_2 \xrightarrow{\text{Mn Salt}} CH_3COOH \quad . \quad . \quad . \quad . \quad . \quad (7)$$

This reaction takes place almost quantitatively to yield acid of 95-98 per cent strength directly.

It has been shown that explosive peracetic acid is formed as intermediate, and efforts must be directed toward a low concentration of this hazardous chemical. Preferred operating temperature is 70-80 C, and catalyst (manganese acetate) concentration is near 0.1 per cent. Jockusch[11] has shown that the catalyst should be in the manganic form to avoid a prolonged induction period.

Acetic acid is recycled to the reactor entrance so that acetaldehyde concentration in the feed is 10-15 per cent. This degree of dilution is made necessary by reaction control considerations.

Either purified oxygen, or air may be used as oxidizing agent. The purity of oxygen determines, of course, the quantity of waste gas and thus the ease of product recovery. Plants employing air as oxidant must resort to operating pressures of 150-200 psig. If reasonably pure oxygen is employed, atmospheric pressure operation is adequate.

Yield is about 95 per cent of theory. The principal by-products are methyl acetate (1-2 per cent), formic acid (0.5 per cent), and water (1-2 per cent). Because of these contaminants, it is necessary to employ acid-proof equipment. The product is upgraded to glacial acetic acid by distillation.

A similar process is employed for the oxidation of n-butyraldehyde to **butyric acid.** The catalyst here is manganese oleate or butyrate. Because the raw material as well as the product in this instance have lower vapor pressure than the corresponding materials in acetic acid production, air oxidation is practicable even at atmospheric pressure.

Because of the difficulties in drying n-butyraldehyde, this feed generally contains moisture. It is therefore neces-

*Note that a *fermentation* method for the direct production of acetic acid from ethanol is in commercial use.

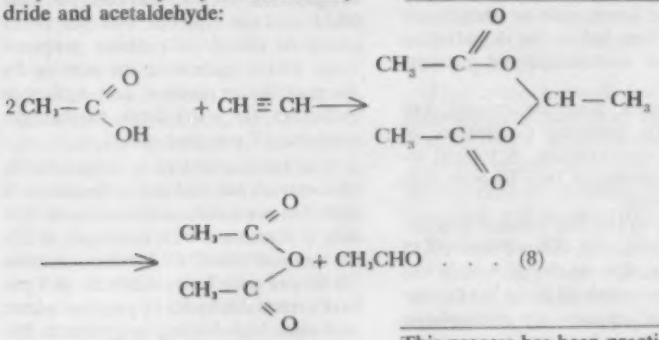
sary to purify the product by careful vacuum stripping. The still bottoms are 99 per cent butyric acid, adequate for most commercial demands, despite the presence of a small amount of condensation products of n-butyraldehyde.

Production of Lower Aliphatic Acid Anhydrides

In essence, this chapter is confined to methods for the production of **acetic** anhydride, which is by far the most important member of this family.

Four petrochemical routes are employed in the commercial production of acetic anhydride. Each has been discussed in some detail by Sherwood, writing in this journal[18]. For the sake of completeness of discussion, we shall here review some of the principal factors involved.

The Ethylidene Diacetate Process. The esterification of acetic acid by acetylene may be guided to the preferential production of either vinyl acetate or ethylidene diacetate. The latter compound may be decomposed catalytically or thermally to yield acetic anhydride and acetaldehyde:



One plant in the U. S. and one in Canada have employed this process commercially. Of late, however, the method has come into disfavor as a route to acetic anhydride.

Production of ethylidene diacetate is carried out in the liquid phase at mild conditions (60-80 C, atm pr). Mercuric oxide, promoted by acids (notably acetyl sulfuric acid) serves as catalyst.

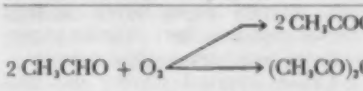
The by-product of the reaction is vinyl acetate. The ratio of products can be varied over wide limits by adjusting the extent to which vinyl acetate is recycled. Where it is desired to produce predominantly ethylidene diacetate, it is necessary to reflux volatile vinyl acetate to the reactor system.

After completion of the reaction, the crude product is freed of mercury sludge and it is neutralized by aqueous sodium acetate. Vacuum distillation serves for purification of the products. Combined yield of EDA and vinyl acetate is near-quantitative (based on acetic acid).

Decomposition of ethylidene diacetate to acetaldehyde and acetic anhydride takes place readily at 50 C in the presence of zinc chloride. The operation is carried out continuously, with the products taken overhead, and rate of feed matched to consumption. High yield is obtained — about 97 per cent of theory anhydride and only slightly inferior recovery of acetaldehyde.

There is a gradual build-up of impurities in the reactor phase and a bleedstream must therefore be taken from time to time to permit undiminished progress of the reaction.

Oxidation of Acetaldehyde. It has been noted above that oxidation of acetaldehyde in the presence of manganese acetate yields acetic acid. By modifying catalytic conditions, this reaction may be made to yield a mixture of acetic acid and acetic anhydride:



This process has been practiced at four commercial plants (of which one is located in the U. S.)

The oxidation is carried out in the liquid phase with suspended catalyst consisting of cobalt acetate and copper acetate in a weight ratio of 2:1. Two commercial methods of operation have been reported.

In one of these versions, a diluent (ethyl acetate) is made part of the reactor charge in order to suppress side reactions which favor acetic acid formation at the expense of anhydride. The second industrial version, carried out in the absence of a diluent yields a less favorable ratio of anhydride: acid.

In either method, conversion per pass is almost complete, and only 2-4 per cent of the acetaldehyde appears in the crude oxidation product. The reaction is carried out at 50-55 C. The solvent process yields an acetic anhydride:acid ratio near 1.2, vs. a ratio of .70-.75 obtained in the absence of diluent.

Acetic Acid Cracking. By far the most important route to acetic anhydride is based on the dehydration of acetic acid. The process involves intermediate formation of ketene which combines with an equivalent amount of acetic acid to yield the anhydride.

$$CH_3-COOH \rightarrow CH_2=C=O + H_2O \quad . . . . . \quad (10a)$$

$$CH_2=C=O + CH_3COOH \rightarrow (CH_3CO)_2O \quad . . . \quad (10b)$$

Two separate reaction stages are employed. The first step — conversion of acetic acid — is carried out wholly in the vapor phase. A vapor-phase catalyst, normally 0.25 wt per cent triethyl phosphate, is employed. The cracker outlet is held between 100 and 200 mm Hg and at 700 C. Per-pass conversion is 80-90 per cent.

To forestall revision of ketene to acetic acid upon cooling, it is necessary to neutralize phosphate contained in the reactor effluent by injection of ammonia. Furthermore, liquid-phase contact of ketene with by-product water must be avoided. The materials of reactor construction may not contain nickel because of this metal's carbonization-promoting tendency.

Ketene, the desired cracker product, is freed of associated water and acetic acid by dephlegmation. It is then reacted with glacial acetic acid in cooled countercurrent absorption towers, operated at 35-50 C. Liquid leaving these towers contains acetic anhydride in 85-90 per cent concentration. This crude product is purified by fractionation.

For the production of 1000 lb acetic anhydride, the overall acetic acid feed is 1330 lb. If credit is given to 90-95 lb acetic acid, which becomes available in weak, recoverable form, overall yield is seen to be approximately 95 per cent of theory.

Acetone Cracking. Ketene, intermediate in acetic anhydride production from acetic acid, may also be obtained industrially by the thermal decomposition of acetone. The process has been reported in use at two U. S. plants and in one British installation.

$$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 \rightarrow CH_4 + CH_2=C=O \quad . . . . . \quad (11a)$$

$$CH_2=C=O + CH_3COOH \rightarrow (CH_3CO)_2O \quad . . . . . \quad (11b)$$

The cracker is operated at 700-850 C, with a per-pass conversion of 25-35 per cent. A pronounced coke-forming tendency can be overcome by doping the acetone feed with a small amount of carbon disulfide.

The hot reactor effluent is shock-

cooled by injection and vaporization of a recycle liquor which is rich in acetic acid. Upon further cooling and condensation, acetic acid and ketene react to yield acetic anhydride. Unconverted acetone and acetic acid are recovered, and the anhydride is purified in a series of fractionating steps.

Miscellaneous Derivatives of Aldehydes and Ketones

Derivatives of Lower Aldehydes

The chief conversion products of C_2 — C_4 aldehydes and their methods of synthesis are considered elsewhere in this series, to wit:

Acetic Anhydride (Part V, section 6)
Acetic Acid (Ibid.)
Butyric Acid and Anhydride (Ibid.)
Ethyl Acetate (Part V, section 8)

A group of lesser important — condensation polymers of acetaldehyde and butyraldehyde — is deemed beyond the scope of the present article series.

To round out the picture of petrochemical derivatives, brief attention must now be given to the syntheses of the following aldehyde-based products:

Crotonaldehyde (and derivative butyraldehyde and n-butanol)
Pentaerythritol
Paraldehyde

Two other aldehyde-derived petrochemicals — chloral and methyl ethyl pyridine — will be discussed in part VI of this series.

Crotonaldehyde, Butyraldehyde, and n-Butanol. In 1954, some 220,000,000 lb acetaldehyde was converted to crotonaldehyde. This product is converted almost entirely to butyraldehyde and n-butanol. In addition, it finds limited application as warning agent in fuel gases and as raw material for the drug butyl chloral hydrate.

Crotonaldehyde's important derivative n-butanol (1953 production: 155,000,000 lb) is a useful solvent for urea-formaldehyde resins, for ethyl cellulose, and for alkyds. It serves as raw material in the production of di-n-butyl phthalate (principally a plasticizer), butyl acetate (chiefly a solvent), and butylamines (above all, chemical intermediates).

Less importance attaches to the production of n-butyraldehyde, intermediate in the commercial synthesis of butyric acid and its anhydride, and of polyvinyl butyral.

Production of Crotonaldehyde. The process for crotonaldehyde synthesis involves homo-condensation of acetaldehyde to acetaldol, followed by dehydration:

$$2\,CH_3{-}CHO \longrightarrow \underset{\displaystyle OH}{\overset{\displaystyle H}{CH_3{-}C{-}}}CH_2{-}CHO \xrightarrow{-H_2O} CH_3{-}CH{=}CH{-}\overset{\displaystyle O}{\overset{\displaystyle \|}{C}}{-}\underset{\displaystyle H}{} \quad \ldots (12)$$

Acetaldol — Crotonaldehyde

Aldolization is catalyzed by aqueous caustic (used in 10 per cent concentration). Commercial plants are operated between 5 and 25 C. Per-pass conversion is 45-60 per cent.

Usual (but not universal) practice is to carry out aldolization in two stages. Most commonly, shell-and-tube reactors are employed (at least for the primary stage) in order to provide the necessary cooling capacity.

Crude acetaldol leaving the final condensation stage (and containing 45-60 per cent acetaldol) is acidified by means of acetic acid or phosphoric acid. It is then fed to the dehydration column for crotonaldehyde production.

Dehydration may be carried out jointly with primary distillation of product crotonaldehyde. A typical installation consists of two 70 plate columns in series.

The feed to the first column is acidified crude acetaldol, diluted with 10-15 per cent recycle water. It enters the column's twentieth plate at 60 C. Operation is at substantially atmospheric pressure with a bottoms temperature of 100-105 C and an overhead, condensing at 20-21 C (i.e. acetaldehyde).

About 30 per cent of the initial aldol is dehydrated in the first column. The bottoms enter the second column, operated with a bottoms temperature of 100-105 C, a top temperature of 85 C, and at atmospheric pressure. Here, the heavy effluent is water containing condensation products. Crotonaldehyde and water pass overhead.

Overall yield in the conversion of acetaldehyde to crotonaledhyde is approximately 90 per cent of theory.

Production of Butyraldehyde and n-Butanol. The hydrogenation of crotonaldehyde may be guided to yield predominantly butyraldehyde or n-butanol.

One commercial version of the process leading to the alcohol employs a catalyst of copper on pumice. The reaction is carried out in the vapor phase at 180-220 C and atmospheric pressure. Reactor feed contains about 3.5 vol per cent crotonaldehyde in hydrogen. Most of the gas is a recycle stream, and only 7-8 per cent of it is make-up (98 per cent) hydrogen.

Substantially complete conversion takes place in a single pass. The reactor effluent is cooled to 5-10 C and the condensate is freed of sludge (catalyst dust) prior to distillation. Yield of crude butanol is 95-96 per cent (on crotonaldehyde). It assays 86 per cent n-butanol, 1-2 per cent butyraldehyde, 1-2 per cent higher products, and 10 per cent water. Standard distillation methods yield butyraldehyde and purified n-butanol. By operating the hydrogenation at mild conditions (e.g. fresh catalyst at 175 C or spent catalyst at 200 C), butyraldehyde formation can be raised to as much as 15 per cent of total conversion.

Crotonaldehyde may be converted preferentially to butyraldehyde by hydrogenation over a mild catalyst. One plant uses an aqueous (40 per cent) slurry of nickel on pumice, prepared from nickel carbonate on pumice by thermal decomposition and hydrogen reduction. On a dry basis, the cataylst contains 13 per cent nickel.

The catalyst slurry is suspended in crotonaldehyde and some limestone is added to neutralize contained acid. The mix is contacted with hydrogen at 25-30 atm and 30-35 C. Product contains 70-80 per cent butyraldehyde, 4-5 per cent crotonaldehyde, 10 per cent water, and some high-boiling by-products. Butanol formation is small. Butyraldehyde is isolated by fractionation.

Pentaerythritol. Rapid expansion of pentaerythritol markets since war's end has created a sizable new outlet for its raw materials, acetaldehyde and formaldehyde. 1953 production of pentaerythritol in the U. S. is reported at 56,000,000 lb, up from 36,000,000 lb in 1950.

Most of this material enters into the production of alkyd resins, synthetic drying oils, plasticizers, and insecticides. Derivative pentaerythritol nitrate has chiefly military uses and accounts, at present, for only a small portion of the market.

Pentaerythritol is obtained by the condensation of acetaldehyde with formaldehyde in the presence of lime (or caustic soda):

$$CH_3CHO + 4HCHO + \tfrac{1}{2}Ca(OH)_2 \longrightarrow \underset{\displaystyle CH_2OH}{\overset{\displaystyle CH_2OH}{CH_2OH{-}C{-}}}CHO + \tfrac{1}{2}Ca(COOH)_2 \quad (13)$$

Typically, the feed to the reactor contains 5 moles 30 per cent ag formaldehyde, 1 mole acetaldehyde, and 1 mole lime. The reaction is carried out at an initial temperature of 18 C (i.e. just below the boiling point of acetaldehyde). After about two hours, the system temperature is raised to 60 C to compare conversion and remove formaldehyde.

Finally, a slight excess of sulfuric acid is introduced to kill the reaction. After filtration, resin-grade pentaerythritol is separated from residual impurities (sodium or calcium formate, etc.) by evaporation and crystallization. This product grade is a mixture of 85-90 per cent monopentaerythritol and 10-15 per cent dipentaerythritol (plus some poly-PE). To produce nitration-grade PE the monomer must be separated from the dimer by fractional crystallization.

Typical yield of resin-grade pentaerythritol (m. pt. 230 C) is 60-70 per cent, based on acetaldehyde. Issoire[17] has reported a yield increase to 85-90 per cent by catalyzing the reaction with copper oxalate at the outset and with cuprous oxide during the finishing (high-temperature) stage.

Paraldehyde. Some importance attaches to paralydehyde, the trimer of acetaldehyde. Because of its higher boiling point (124 C at atm pressure), this liquid is transported more easily than monomeric acetaldehyde to which it may be readily re-converted. Paraldehyde serves, furthermore, as one starting material in the synthesis of methyl ethyl pyridine (cf Part VI of this series).

The trimerization of acetaldehyde to paraldehyde is carried out in the presence of a small amount of sulfuric acid. The reaction is carried out in paraldehyde solution in a suitably cooled vessel. The product is neutralized (by sodium acetate or by ion exchange), and is distilled for separation from unreacted acetaldehyde and of heavy by-products.

Miscellaneous Derivatives of Lower Ketones

Only two ketones, acetone and methyl ethyl ketone, are primary derivatives of $C_3 - C_4$ hydrocarbons. Higher ketones, among which methyl isobutyl ketone is of particular importance, are obtained from lower aliphatic hydrocarbons by less direct methods than those applicable to the first two members of the series.

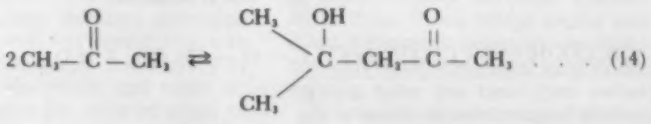
Confining our attention to acetone and methyl ethyl ketone, we have noted that only acetone plays an outstanding role as chemical intermediate.

Diacetone alcohol, together with its derivatives, consumes slightly more than one-half of all acetone which is employed as raw material to chemical syntheses. This group of compounds will be the subject of discussion in the present section. In addition, we shall deal with miscellaneous acetone-derived chemicals, notably isophorone and bisphenol-A.

Production methods for ketene, the second-largest chemical consumer of acetone have been discussed above. Acetone cyanhydrin, accountable for 10 per cent of chemical acetone consumption, will be dealt with in Part VI.

Diacetone Alcohol. Diacetone Alcohol is a good solvent for cellulose acetate, nitrocellulose, penachlorophenol, etc. Its principal use is, however, as intermediate in the production of mesityl oxide, methyl isobutyl ketone, and methyl isobutyl carbinol.

A condensation reaction underlies the manufacture of diacetone alcohol:



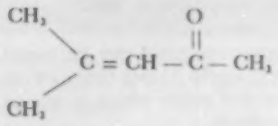
(14)

The reaction is promoted by alkalies. Caustic soda has been used for this synthesis on an industrial scale, but this has a number of drawbacks among which low yield (75-80 per cent), mechanical difficulties, and high caustic consumption are most objectionable.

An alternate version employs water-insoluble hydroxides (e.g. calcium hydroxide) on a carrier as fixed-bed catalyst.

The reaction equilibrium favors diacetone alcohol formation at lower temperatures, but even at 0 C, the equilibrium mixture contains only 22.9 per cent of the desired product. A high recycle ratio of acetone is therefore necessary.

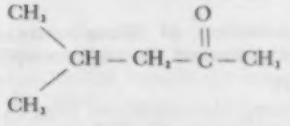
Mesityl Oxide



is an outstanding solvent for polyvinyl chloride acetate resins and for nitrocellulose. It is obtained by dehydration of diacetone alcohol at 100-120 C, and in the presence of a weak acid.

In its own turn, mesityl oxide finds its foremost value as chemical raw material, notably in its conversion, by mild hydrogenation, to

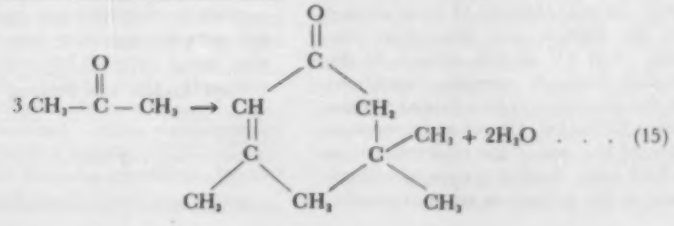
Methyl Isobutyl Ketone



This ketone is an important solvent for a number of resins, as well as for DDT, pyrethrum, etc. It has other markets of importance as dewaxing agent for lubricating oils, as denaturant for ethyl alcohol, and as dispersant for organosol-type resins. Hydrogenation of MIBK is the route to

Methyl Isobutyl Carbinol, again a useful solvent, a frother in ore flotations, and an intermediate in the production of a number of esters among which methyl isobutyl acetate figures most prominently.

Isophorone is an outstanding solvent for nitrocellulose and for vinyl chloride-acetate resins. It is produced by the self-condensation of acetone:



(15)

More drastic conditions are needed than for the self-condensation of acetone to diacetone alcohol (g.v.). Aqueous caustic soda (2 per cent conc.) serves as catalyst in the liquid-phase process for isophorone synthesis.

The organic feed material and the aqueous catalyst are pre-heated and fed separately to a well-agitated vessel where the reaction is carried out at 140-170 C. After reaction time (approximately one hour for 25 per cent conversion), the effluent is cooled and the two liquid phases are separated. The aqueous layer is fortified and recycled to the reaction stage. The organic phase must be neutralized with a weak acid prior to purification of its components.

Isophorone yield can be raised (to approximately 55 per cent) by recycling mesityl oxide which is one of the by-products.

Bisphenol-A, condensation product of acetone and phenol, has an important potential due to the rapid rise of epoxy resins which constitute its end use.

In the production of bisphenol-A, the stoichiometric ratio of phenol to acetone is 2:1, but for best yield, a ratio of 3-3.5 is taken.

Anhydrous HCl serves as catalyst. The main part of the reaction is carried out at 15-30 C. Product yield is 80-90 per cent.

Production of Miscellaneous Oxygenated Petrochemicals

Ethers

Among ethers derivative from C_2 — C_4 hydrocarbons, the diethyl and diisopropyl compounds occupy the foremost position.

Leading is diethyl ether with a 1953 production volume of 47,300,000 lb. Its peak U. S. production during any year was achieved in 1945 when output was 76,000,000 lb.

Diethyl ether is an outstanding industrial solvent. As such, it finds application in the production of nitrocellulose, gums, alkaloids, perfumes, etc. Other applications include the use of diethyl ether as starting fuel for diesel engines, as azeotroping agent in the production of absolute alcohol, as reaction medium in Grignord syntheses, and (in highly purified form) as anesthetic.

Practically the entire output of diethyl ether is obtained as by-product from the manufacture of ethyl alcohol by the sulfuric acid absorption process (Part IV of this series). If the market demands, operating conditions in this process may be adjusted to raise ether formation. Of prime importance toward this end is the maintenance of a high ratio of ethyl groups to sulfuric acid in the hydrolysis stage (typically, the ratio is 3.1 in the preferential production of diethyl ether). Toward the end of achieving a high ratio, product ethyl alcohol is recycled to the process.

The specific dehydration of ethyl alcohol may also be carried out by bubbling alcohol vapor through 66 deg Be sulfuric acid at 135-150 C. This is the Barbet process which was formerly the predominant factor in U. S. ether production but has now receded to a minor position.

Dehydration of alcohol to ether over a fixed-bed catalyst has been the subject of some recent investigations, but there is no evidence of its industrial adoption. Carrying out the reaction over alumina, Feilchenfeld[14] was able to obtain conversion up to 70 per cent by operating at 80 atmospheres, the optimum pressure, and at 330-350 C. Dehydration of ethyl alcohol to ethylene is responsible for most of the yield loss.

1953 production of diisopropyl ether was 5,000,000 lb. Most of the output is used in various solvent applications (e.g. as extractant for acetic acid or as diluent in the lacquer and naval stores industries). Some diisopropyl ether is blended into gasoline.

Diisopropyl ether is obtained solely as byproduct of isopropyl alcohol production (cf. Part IV). The extent of its formation may be controlled by adjustment of operating conditions, in accordance with market requirements. In general, the market situation demands operation for minimum ether formation (approximately 6 per cent of alcohol yield).

Esters

Among derivatives of C_2 — C_4 aliphatics, only vinyl and ethyl acetate are truly large-volume members of the important ester family.

Vinyl Acetate. Markets for vinyl acetate have been characterized by outstanding growth during the post-war decade. In point of sales volume, vinyl acetate is today the most important organic ester. 1953 end use distribution has been estimated as follows[15]:

Vinyl Acetate Use Pattern, 1953
(Millions of Pounds)

Polyvinyl acetate	45.0
Polyvinyl alcohol	27.0
Polyvinyl formal and butyral	20.0
Polyvinyl copolymers	15.0
	107.0

Use of polyvinyl acetate in rubber-base paints has been the most significant single growth item. It also serves as adhesive for wood and paper and has important markets as sizing for textiles, paper, etc.

Derivative polyvinyl alcohol finds extensive use in the textile industries. The chief end use for polyvinyl butyral is as interlayer in safety glass.

Production of vinyl acetate follows the pattern for the synthesis of ethylidene diacetate which is outlined above. The principal difference is the employment of a technique in which vinyl acetate is withdrawn from the system as quickly as it is formed.

An alternate process, which has been gaining favor in recent years, involves the vapor-phase reaction of acetic acid and acetylene over a catalyst consisting of zinc acetate on active charcoal. Reaction temperature is 170-210 C. Yield (on acetic acid) is reported at 97-99 per cent.

Ethyl Acetate. Sales for this ester have been characterized by a fairly constant volume in recent years. 1953 production was 80,700,000 lb (85 per cent basis). Ethyl acetate serves widely as fast-drying nitrocellulose solvent. Other important uses are also related to its favorable characteristics as solvent.

A useful method for ethyl acetate production involves the Tschitschenko synthesis from acetaldehyde:

$$2CH_3CHO \rightarrow CH_3\overset{\overset{O}{\|}}{C}-O-CH_2-CH_3 \quad . \; . \; . \; . \; . \; . \; . \; . \; (16)$$

Catalyst for this reaction is aluminum ethoxide promoted by aluminum chloride and zinc oxide. The conversion is carried out at 0 C in the presence of ethyl acetate and ethyl alcohol. Yield is reported at 97 per cent.

A continuous process for the manufacture of acetic acid is described by Backhaus (16): An equilibrium reaction is involved:

$$CH_3COOH + CH_3CH_2OH \rightleftarrows CH_3\overset{\overset{O}{\|}}{C}-O-CH_2CH_3 + H_2O \quad . \; . \; . (17)$$

It is essential that water be removed from the system as it is formed. In the process described by Backhaus, the raw materials are blended and fed, via a preheater, to an esterification column which is operated with reflux. A ternary mixture (20 per cent ester, 10 per cent water, 70 per cent alcohol) is taken off at the top. Watery slop is allowed to concentrate in the column's bottom.

* * *

FIG. 1. Man in shirt sleeves, circle, is standing at airtube station that serves machinists' section in Esso's maintenance building, Baton Rouge, Louisiana, plant.

P 769.2

Automatic Tube System

Prevents "Log-Jams" in Maintenance Plant

Carroll Hennessy
The Lamson Corporation

KEEPING a maintenance operation at top efficiency becomes a costly problem as the size of the operation increases. The time needed to schedule work, requisition materials, issue instructions and keep records tends to rise disproportionately with the number of people involved. As the physical size of the plant increases, communications become less direct and take more time. Delays in the delivery of paperwork, blueprints, and other information from the point of origin to the point where they're needed sap away a hidden but costly chunk of productive time from the work day.

An excellent example of how streamlined communications can raise the working efficiency of a maintenance organization is provided in the central mechanical building of the Baton Rouge refinery of Esso Standard Oil Company. The building is served by a high capacity, fully automatic pneumatic tube communications system which is the first industrial system of this type to be installed in the United States.

EXCLUSIVE

Third only to Iran's Abadan installation as the world's largest refinery, the Baton Rouge installation operates a maintenance service building in which parts of six craft divisions, consisting of more than 300 workmen and 17 supervisors, are employed. This building is 600 ft long, 235 ft wide and 40 ft high, containing three continuous parallel bays running the entire length of the building (Fig. 1). It is completely equipped with the latest machine tools, three 15-ton bridge cranes and other equipment necessary to maintain and repair equipment used in the refinery.

Because of the size of the building and the distances between the work areas, record rooms and store rooms, Esso took steps to streamline communications as soon as the building went into operation. Particular attention was paid to developing procedures for transmitting requisitions and delivering parts and materials between the 300 workmen and the stock room. Esso supervisors realized that unless the stock room procedures were adequately systematized, many man-hours would be wasted because of confusion, delays, and frequent trips by workmen to the distant stock room. Accordingly, a system was set up using a fork-lift truck as the link between the workmen and the stock area.

To obtain parts and materials from stock, the workmen in the various craft areas filled out requisitions. These requisitions were handed to the lift truck operator who made the rounds of all the craft areas in the shop on a 15-minute schedule throughout the day. The truck operator would hand in the requisitions to the stores order clerks, who added necessary identifying information and sent them to the adjacent stock room. Meanwhile, the truck operator stopped at the stock room and picked up the items ordered from the *previous* batch of requisitions, which he delivered to the craft areas. On his return to the stock room 15 minutes later, he obtained the items for the requisitions just processed.

Although this routine cut down much unnecessary traffic between the craft areas and the store room, it nevertheless was an expensive way to transport correspondence. More important, there was no convenient way for special or rush ressages to travel between the craft areas and the stores order section. For example, if the order office raised some question about a requisition, the message would be carried by the driver, who might pick up the reply

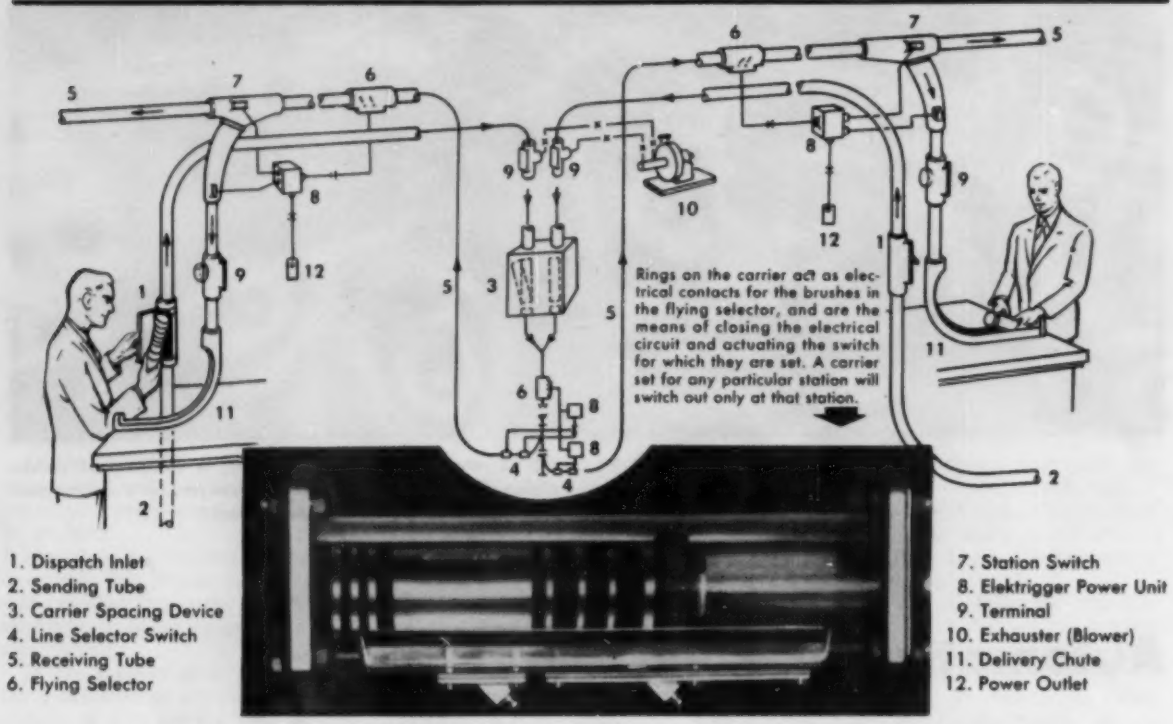

Rings on the carrier act as electrical contacts for the brushes in the flying selector, and are the means of closing the electrical circuit and actuating the switch for which they are set. A carrier set for any particular station will switch out only at that station.
1. Dispatch Inlet
2. Sending Tube
3. Carrier Spacing Device
4. Line Selector Switch
5. Receiving Tube
6. Flying Selector
7. Station Switch
8. Elektrigger Power Unit
9. Terminal
10. Exhauster (Blower)
11. Delivery Chute
12. Power Outlet

FIG. 2. Diagrammatic drawing, showing the main elements in the airtube automatic system.

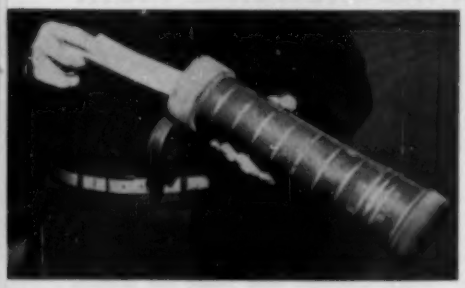


FIG. 3. Placing a message in a carrier, equipped with metal rings by which it is directed to its proper destination.

15 minutes later. In all, an hour might have elapsed before the requested items were finally delivered. In many instances, the specialized material man of the particular craft section involved would take the requisitions to the stores order section himself to make certain there was no misunderstanding. As a result, he did a lot of walking. This wasted a considerable amount of valuable time for what were essentially errand-running missions.

To eliminate this expensive operation and to speed up requisition handling still further, Esso looked into means of improving its communications procedures. They investigated the possibility of installing a pneumatic tube system to link the various craft areas with the stores section and with the various record-keeping sections that are concerned with maintenance operations. A cost analysis showed that such a tube system would pay its way economically by saving much of the time theretofore expended by delays and walking around the shop.

About the time this analysis was completed, Lamson Corporation of Syracuse, New York, announced the development of an automatic pneumatic tube system to supplement its line of manual airtube systems. A second analysis was made which showed that, because the automatic system needed no dispatcher it could be justified over the manual system.

To understand why this is so, it is necessary to look into the operation of a pneumatic tube system. Basically, these systems are steel tubes through which a stream of air is moved continuously by a motor-driven exhauster at one end of the tubes. This airstream furnishes the motive power that transports cylindrical carriers (which contain the items being delivered) through the tubes. To get two-way communications between two points, it is usually necessary to use a pair of tubes, one for sending, the other for receiving the carriers.

In a large system set up to handle two-way communications between each of six to eight stations, it is usually more economical not to connect each station with every other station, but to channel all tube lines into a central desk. With this arrangement, no two stations are linked directly. To send a carrier to Station B, Station A inserts the carrier into the sending line which delivers it to the central desk. An attendant at the central desk in turn dispatches the carrier through its sending line to Station B. If B wishes to reply to A, the procedure must be repeated with the central desk as intermediary. Thus, in a system with six stations, a total of 12 tube lines radiating from the central desk interconnects all six sta-

The Author

Carroll A. Hennessy, manager of the commercial division, joined Lamson Corporation in 1931 after receiving his bachelor's degree in mechanical engineering from Syracuse University. In his 24 years with Lamson Corporation, he has served as the head of contract engineering, manager of development and research and recently was appointed to his present position.

Hennessy holds a professional engineers' license in the state of New York. He is well-known as a member of the American Society of Mechanical Engineers and in many other similar organizations, having written a number of articles for these groups.

FIG. 4. Carrier being received at machinists' control point.

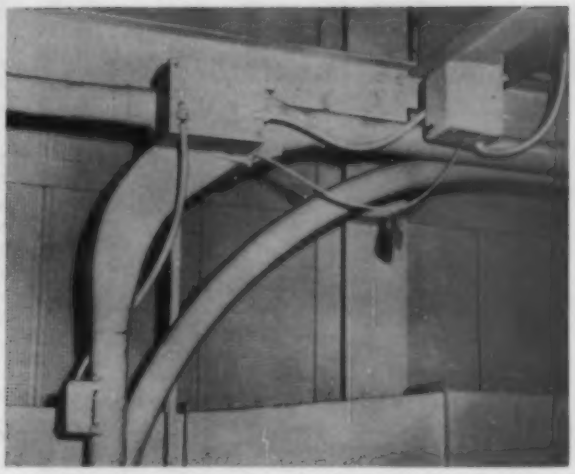


FIG. 5. Deflector control for carrier at a receiver by-pass line.

tions. Without the central desk, the six-station system would require 30 tube lines, larger blowers and involve higher power costs to provide the same interconnecting service among the six-points.

The automatic pneumatic tube system developed by Lamson Corporation creates further economies in the installation and operation of large pneumatic tube systems. Cost are lowered because the new system requires no central desk, eliminates the need for desk attendants and uses less tubing than does a conventional system to interconnect the many stations. In essence, the automatic switch tube system is composed of two continuous lines for sending and receiving that encompass all the stations in a loop (see Fig. 2). Each station has both a short length of inlet and outlet by-pass tubing that connects the station to the main loops of tubing. Usually eight stations comprise a loop and, where additional stations are required, the system will have two or more loops, all intersecting at one common point.

Once the proper settings are made on the carrier, it delivers itself automatically to its destination. Along the outside circumference of each carrier is a set of three movable brass rings and seven equally spaced fixed rings (Fig. 3). Two of the movable rings are adjustable to indicate *letters* (which designate loops) and the other movable ring indicates *numbers* (which designate particular stations within a given loop). When the sender dials a particular number and letter, the movable rings become electrically connected to two of the fixed brass rings by the alignment of metal contacts inside the tube. As a result, each coded setting creates a distinctive physical spacing between the brass rings. This spacing, as will be discussed shortly, "tells" the various selectors in the system how to route the carrier.

When the carrier is placed in the dispatch inlet (Fig. 4), it travels around the loop until it reaches a spacing device that automatically intercepts the carrier and holds it for 10 seconds before releasing it. This device is one of the brains of the system, since by intercepting every carrier it prevents two carriers from arriving at the same point in the system simultaneously and thereby eliminates the possibility of jams.

After the carrier is released from the spacing device, it moves through a "flying selector" which, in the case of multiple loop system, switches the carrier to the proper loop. The selector contains paids of feelers, each pair having a distinctive spacing. The switch is energized as the carrier passes under the pair of feelers having the same spacing as the pair of brass rings which were connected by the dialing.

The carrier then proceeds along the loop, coming in contact with a succession of feelers, each set being located about 15 feet ahead of the by-pass delivery line leading to the individual stations. When the carrier arrives at the particular set of feelers whose spacing corresponds to the spacing of the connected rings on the carrier, an electric circuit is completed, which trips a deflector in the line ahead of the carrier. The deflector routes the carrier into the receiving line of the station selected (Fig. 5). The carrier drops by gravity into a delivery chute, tripping a circuit breaker as it passes. This circuit breaker de-energizes the deflector solenoid and permits subsequent carriers destined for other stations to pass that station. One of the operating advantages of this automatic system is that all of the electrical controls are local at each station (Fig 6). Therefore, in the event of electrical failure, the difficulty can be located immediately at the particular station affected, thereby saving a considerable amount of troubleshooting.

The Lamson automatic switch tube system at Esso consists of two interconnecting loops. One loop contains six stations: The dispatcher's office (Fig. 7); machinists' section; tube bundle and safety valve section; electricians' section; boilermakers' section; and the pipefitters' section. The second loop contains two stations: The equipment record room and the stores order office, the latter being the busiest station in the whole system. The second loop can accommodate additional stations when needed. The larger loop is powered by a 7½-hp exhauster, the smaller loop by a 2-hp exhauster. The running time for a carrier traversing the longest possible distance in the system is approximately 40 seconds.

With the automatic switch tube system, the efficiency of Esso's maintenance operatings has increased in many significant respects. It has found that the average delivery time for paperwork, requisitions, reports, and blueprints has been reduced from 30 to 45 minutes to approximately 30 seconds. Since the system handles about 100 communications an hour, taking an average for the entire day—but several times that number during peak hours in the morning—the total time saved by eliminating walking trips through the building and delays in the transmission and receipt of paperwork and blueprints amounts to several hundred hours. On a two-shift operation, these savings can be expected to double with only a negligible increase in system operating costs. ★ ★ ★

PETROLEUM PRODUCTS: Nature and Properties

Chapter 12

Dr. V. A. Kalichevsky
Consulting Chemical Engineer

SPECIFICATIONS and properties of the fuels and special products discussed in this chapter are in all cases the outgrowth of years of experience, of errors made and corrected, of difficulties and problems solved, in the use of these products. Equipment in which the products used change; customer wants change; crudes processed change in source and kind. Specifications are never static, are always in process of change, and improvement, and refining processes are improved. It is safe to say not a single specification here mentioned has been perfected, but they indicate the best that the industry can produce competitively at prices customers are willing to pay. A thorough understanding of the meaning of specifications and of the use conditions products must meet is fundamental knowledge for every refiner.

Many types of fuels and solvents are made from petroleum to meet the requirements of the highly diversified modern machinery and to satisfy the demands of the customers. Progress in the mechanical equipment and operating technique requires frequent reformulation of the established lines of petroleum products and the creation of new ones. Research in the petroleum industry is never idle.

Thousands of products are made from petroleum and many of them are fuels and solvents. The most important fuels, other than gasoline, can be divided into kerosines, diesel fuels, jet fuels, distillate fuel oils, and residual fuel oils. Solvents are classified according to their specific applications, which determines their composition.

Kerosines

Kerosine is used in many domestic appliances as a source of light or heat. It is handled around homes and farms by persons seldom familiar with the danger involved in using flammable liquids. For this reason, it must be a safe fuel. It should not ignite from an open flame but burn when it is lighted in special equipment. Kerosine meets these two contradictory requirements as closely as can be expected from a material of this nature. It has a high "flash point" but a comparatively low boiling range.

Flash point of kerosine is normally 120 F or higher. This means that it must be heated to at least this temperature before it will vaporize in sufficient quantity to form an explosive mixture with air. Even under these conditions the main body of the kerosine will not catch fire when the flash occurs. It must be heated some 40 or 50 degrees higher than the flash point in order to reach the "fire point," i.e. the temperature at which it begins to evaporate at a rate required to maintain a continuous flame. Only unexcusable carelessness, like storing kerosine close to an oven or spilling it over a flame, can create such dangerous conditions.

Kerosine must vaporize easily, however, when it is fed to the flame through the wick of a lamp, as otherwise it will not burn. This limits its boiling range. In its turn, the boiling range sets a limit to the maximum flash point kerosine can have for meeting this requirement. The boiling range of kerosine is normally between 350 and 550 F.

Kerosine is lifted to the flame by the wick. This lifting effect is due to capillary attraction, a phenomenon observed only in tubes of very small diameter. The wick contains a large number of such tubes or passages, i.e. capillaries. Liquid is attracted to these capillaries and rises well above the level it occupies in a container. The ease with which kerosine flows through the capillaries depends much on its fluidity. For this reason, kerosine must possess a certain fluidity to reach the flame before the wick itself begins to burn.

The flame produced by kerosine must be bright and should not smoke. This is a very important requirement that depends on the kerosine composition. Kerosine must consist of hydrocarbons rich in hydrogen. Aromatic and unsaturated hydrocarbons burn with a smoky flame and must be removed. The unsaturated hydrocarbons may also polymerize and form gummy deposits that will plug capillaries in the wick. Sulfur compounds may attack the wick or form deposits in the funnel if they are present in appreciable quantities. Kerosine should not be corrosive because the acids may attack the metallic parts of the lamps, and it should leave no ash on burning. The odor of kerosine should not be objectionable to persons handling it.

Quality of kerosine and other petroleum products varies with the demand of the market where they are sold. For instance, kerosine exported not so long ago to China had to have a very transparent color, much lighter than that of water. The Chinese were also demanding kerosine that had a strong odor and burned with a smoky flame. These requirements were opposite to those of the American and other markets.

Diesel Fuels

Diesel fuels are used in diesel engines. These engines are different from automobile engines, although they seem to be similar as they burn fuels directly in the cylinders. A short time before World War II, and during the first years,

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

attempts were made by the Germans to use these engines in airplanes with a considerable degree of success. However, such planes could not develop all the characteristics necessary for military purposes. If the two engines are so similar, what difference in their construction accounts for their needing entirely opposite types of fuels?

The true diesel engine does not use sparks for igniting fuel in the cylinders and — even more important — liquid fuel is injected into the cylinders. The heat required to ignite the fuel is obtained by compressing the air in the cylinders. When gases are compressed, much heat is evolved and by compressing them to a small volume as compared to the original, a temperature is reached that is sufficiently high for exploding the air-fuel mixture. Compression ratios must be at least 15 to 1 but preferably higher to attain this condition.

Fuel is injected into the cylinders in the form of a stream after the air is compressed. Although the time of injection is short, it is still sufficient to burn the fuel when it first hits the hot air, but before the remaining portion of the fuel has time to reach the cylinder. This produces a series of very sharp but small explosions that result in the development of a gradual pressure on a piston.

When gasoline of high quality is used in such engines, it will not burn at once for the reasons explained later. However, as more and more of it accumulates in the cylinder, the rate of burning will become so rapid that it may shatter not only the piston but the whole engine. Disasters of this type happened during the early stages of diesel engine development when the engines blew up and their fragments killed the operators.

This shows that diesel engines require a different type of fuel from gasoline engines. Fuels that are best for gasoline engines are not suited for diesel, while diesel fuels cannot be employed in gasoline engines. Diesel fuels are rated similarly to gasoline, employing the cetane scale, which has been developed on the same principle as the octane scale but with the following difference.

Cetane gives an excellent performance in diesel engines and consequently a very poor performance in automobile engines. For this reason, it has been assigned the value of 100 cetane number. Another compound, known chemically as alpha-methylnaphthalene, which gives exceptionally poor performance in diesel engines and has the anti-knock characteristics of a good fuel for gasoline engines, has been assigned the value of O cetane number. Cetane numbers refer to the percentage of cetane in a mixture of these two compounds which matches the performance of the fuel under investigation. The cetane scale is also different from the octane scale in that the best diesel fuels on the market range somewhere between 50 and 60 cetane number, seldom exceeding these limits. Gasolines having octane numbers considerably in excess of 100 are by no means rare.

Straight-run petroleum products are satisfactory for the present design of diesel engines, but the cracked products seldom are. The cetane number of diesel fuels can be improved by the addition of chemicals, such as amyl nitrate or organic peroxides. Amyl nitrate is available commercially as a diesel fuel additive, same as tetraethyl lead is available as a gasoline additive. The effect of cetane number improvers on the ignition quality of fuels is the reverse of tetraethyl lead.

High-speed diesel engines operate at above 1500 rpm and are employed in trucks and buses. They require diesel fuels of the highest cetane number, i.e. in the 50-60 cetane number range. Medium-speed engines operate between 500 and 1500 rpm and are used in tractors, power shovels, locomotives, marine power generators, pumps, and industrial units with a flexible power output. They are usually

FIG. 1. Fractionator columns from which a number of special products, solvents, etc., are made from refining or natural gasoline light fractions.

satisfied with fuels of about 45 cetane number. Slow-speed diesel engines operate below 500 rpm and find applications in very large stationary power units and marine installations. They operate on fuels of about 40 cetane number. The quality of diesel fuels in the high-speed diesel engines must be high in other respects because of the nature of the service.

Diesel fuels for the high-speed diesel engines must easily vaporize or atomize, i.e. they must form a fine spray when injected in the cylinder. This depends mainly on the distillation range and fluidity of the fuel. Diesel fuels for high-speed engines boil within the kerosine range, and their viscosity is about 30-35 SUS at 100 F.

Viscosity is a property of a liquid opposite to fluidity. It measures the resistance of a liquid when it is forced to flow. Special instruments are used for expressing viscosity in reproducible units, and it is important to specify which instrument was used in taking these measurements. Different instruments give different readings which are not easily convertible. Saybolt Universal viscosimeter is used in this country. It measures the time required for 60 cu cm of oil to flow through a standard opening.

Viscosity of diesel fuels is also important because these fuels lubricate some parts of the engine. High-grade fuels should not form carbon on burning, and they must be stable, noncorrosive to metals of which the engine is made, and must be free from water and foreign matter. Pour point, i.e., the lowest temperature at which the oil still flows, must be low if the oils are used in winter. In this connection, it is of interest that pure materials having cetane numbers above 80 cannot be used in cold weather because they solidify at above 0 F.

Diesel fuels used around towns in trucks and buses must burn without smoke and odor. This means that they should burn completely. Mostly for this reason, the sulfur content of diesel fuels is kept below 0.5 per cent. Complete combustion is a very difficult problem to solve, and, in this connection, the engine design is important not to produce "smog."

The diesel engine was invented by Rudolf Diesel in 1893 and was successfully demonstrated in 1897. Since that time, a number of other engines have appeared that occupy a position intermediate between diesel and gasoline engines. For instance, fuel may be mixed with air before

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

FIG. 2. Vapor (or gas) recovery system, from which many special fuels and solvents are made from refinery light vapors and liquids.

being injected into the cylinders, or it may be ignited by an electric spark. Such diesels, if the name can still be applied to these engines, which are really only semi-diesels, require intermediate types of fuels with respect to knock rating.

Diesel engines are used for a tremendous variety of purposes. In many instances the primary purpose of employing these engines is the saving in fuel cost. Specifications for high grade fuels, however, are not easy to meet, and the cost of distributing them is high because the quantities handled are much smaller than those of gasoline. In addition, some states tax diesel fuels at the same or even higher rate than gasoline. This taxation removes the last advantage that high-speed diesel engines possess.

Jet Propulsion Fuels

Another type of engine developed in Germany during the last stages of World War II employs jet propulsion. Considerable progress has been made since that time in this country. Airplanes equipped with these engines move at extraordinary speeds that are faster than the velocity of sound, or over 750 mph. Special pilotless flying devices are already achieving twice the speed of sound. The commercial value of such engines for the future is undetermined, as information for such an evaluation is not yet available. However, jet planes for carrying passengers were built. This means that the high fuel consumption characteristic of early jet engines has been reduced to a more reasonable level.

Besides the ability of developing tremendous speeds, jet-propelled planes do not need the presence of atmosphere to support their weight. As a matter of fact, air is a handicap and not an asset because it offers resistance to the movement of the rocket. Oxygen necessary for combustion of the fuel, however, must be supplied to such a machine. Instead of oxygen, other, more powerful combinations of chemicals can be used.

Jet-propulsion engines are simple in principle. Explosion develops a shock that forces the rocket plane to move while gases escape in the opposite direction. The action is similar to that of the recoil of a firearm, the gun acting as the plane and the explosive as the jet-propulsion fuel. The difficulty, however, is in developing the minute details of the equipment design that would permit maximum fuel utilization.

When the jet-propulsion engines were in the early stages of development, opinions were expressed that they will be indifferent to the type of fuel used. Similar hopes were held previously for diesel engines, but they met with considerable disappointment. The optimistic claims with respect to fuel quality are often made when new machinery is just offered to the public. Mechanical difficulties encountered in making it practical overshadow the importance of proper selection of fuels and lubricants that have only minor effects on the engine performance at that time. With the improvements in engine construction, the effects of the fuels and lubricants become apparent. As a result, specifications for petroleum products are tightened. This tightening of the specifications may go to such an extreme that they may be slackened eventually. Changes in jet fuel specifications in the past seem to follow this general pattern.

The present jet fuel specifications require products that represent the heavier portions of gasoline and the lighter portions of kerosine but without strict limitations on the quantities of materials boiling outside of these ranges. The freezing point of these fuels is kept below —76 F because of the low temperatures encountered at high altitudes. Vapor pressure must be low, a fraction of an atmosphere, to prevent fast vaporization in flights high above the ground. Sulfur content of these fuels is kept below 0.4 per cent in order to avoid corrosion of equipment built of cheap metals. The fuels must also be non-corrosive to the materials with which they are in contact before they are burned. Other specifications cover oxidation stability, content of aromatic hydrocarbons, the quantity of water they can hold in solution before separation in the form of ice, and metal content. Future will show how many of these and other additional specifications are essential.

Fuel Oils

Two common types of fuel oils are recognized by the refineries: Light distillate fuel oils employed in domestic burners and similar equipment, and heavy, or the so-called bunker fuel oils, which represent residual petroleum products. The distillate fuel oils are prepared with greater care than the residual oils because of differences in burner requirements and in conditions of service.

Distillate or domestic fuel oils boil within the kerosine and light oil range. Several grades are available for use in different types of burners. In some burners, the same oil is used both as fuel and as a lubricant, which makes viscosity specifications important. The home owner must know what grade of oil he wants if he expects to have his burner in good working order. Complaints coming from the users of the oil are often beyond anybody's control except the customer himself. For instance, some of the users will never clean their fuel oil tanks; or, they pump them dry, forgetting to renew the oil supply at the proper time. The sediment in tanks, sometimes arising from sources other than the oil, will clog the burner. Water from the atmosphere may condense in the tanks if they are not protected, contaminating the oil and causing uneven burning and a sputtering flame.

The oil leaving the refinery must be clean and stable over a reasonable period of time. It should form no sediment in storage and deposit no measurable quantity of ash on burning. It must flow at low temperatures, which are encountered in storing it during the winter months. Sulfur content can be relatively high because sulfur dioxide formed on combustion is corrosive only in the presence

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE

of water. Condensation of water seldom if ever occurs in the stacks. The oil should not corrode the materials of which the furnaces and tanks are built. Domestic fuel oils should burn without producing excessive quantities of smoke. For this reason, they should not contain large volumes of aromatic hydrocarbons.

In addition, the domestic fuels must pass a few other requirements that are not directly related to their burning qualities but are imposed by the home owners. These fuels must have a light color and an attractive appearance. Their odor should not be objectionable if the customer spills the oil in a cellar accidentally. The flash point must be at least as high as that of kerosine for fire protection. Domestic fuel oils are made of petroleum fractions slightly heavier than kerosine, i.e. they include most of the kerosine cut and some higher boiling materials.

Residual fuel oils are obtained after most or all the gas oil is removed by distillation. The users of these oils are mostly interested in low-cost liquid fuels, and very few buyers are willing to pay the extra price that must be charged for refined products. For this reason, most of the residual fuel oils may be regarded as rejects from refinery operations and are sold as bunker fuel oils. They are used by ships, locomotives, and in heavy, stationary engines. Engines of this type are built to burn almost any type of fuel.

Bunker fuel oils are sold below the price of crude oil. This is possible because all fractions that can be used for preparing gasoline, kerosine, and other valuable products are utilized by the refineries. The bunker fuel oils are heavy, their sulfur content is high, they may contain sediment and even small quantities of water, and form ash on burning. In preparing these oils, two problems might be encountered by the refineries—high density of the product and compatibility.

After the desirable fractions are removed, the refinery residuum oils are frequently heavier than water. In tanks, the water will thus float above the oil layer. The customer may buy an oil that is heavier or lighter than water. The water that separates from the oil may thus be drawn off from the top or from the bottom of the tank with the sediment accumulating at the bottom. This introduces operating inconveniences when the cheap oil is used. Most of the bunker fuel oils on the market are heavier than water. Occasionally oil that is lighter than water can be bought at distress price. The buyer must know what he is doing by mixing such materials and not complain if bad performance results.

Residual fuel oils may not be compatible, i.e., on mixing different products, large quantities of materials may precipitate and form a heavy sediment. The tanks from which the residual oils are pumped to the burners are often supplied with stirrers to provide a uniform feed.

Solvents

A large variety of solvents is made from petroleum. These solvents vary widely in their boiling range and other characteristics depending on the purpose for which they are employed. For this reason, they may be regarded as specialties.

Most of the solvents are comparatively narrow petroleum fractions boiling within the gasoline or kerosine range. Absence of light materials reduces the fire hazard and lowers the handling losses. Freedom from the high-boiling materials insures complete vaporization of solvents, which should leave no oily residues on evaporation.

Petroleum solvents may be divided into two general groups, those that represent mixtures of saturated hydrocarbons and those rich in the aromatic hydrocarbons and having a high solvent power toward many substances. Whenever possible, solvents made up of saturated hydrocarbons should be used because the aromatic hydrocarbons, like benzene or toluene, must be handled carefully. They are a health hazard to men who are exposed continually to their vapors. Solvents can be prepared from petroleum, which in their composition and properties are no different from those made by the coal-tar industry.

FIG. 3. Light fuels, solvents and "thinners" are taken from such towers as these illustrated. The interrelationship between these towers in the flow of the charge stock is intricate, and operation is a carefully planned and executed routine.

Cleaners' or Stoddard solvent is probably the best-known solvent used by the dry-cleaning establishments and in homes. It is a petroleum fraction boiling between 300 F and 400 F. The solvent is very stable and is used over and over again by the commercial enterprises. When the solvent becomes dirty, it is purified by distillation. Requirements that this solvent must meet are directly related to its applications.

The boiling range of the Stoddard solvent was chosen so as to represent the heaviest petroleum fraction that will still evaporate easily into the atmosphere but without creating a fire hazard. It is made of saturated hydrocarbons and presents no health problems. The solvent must be stable and non-corrosive. Its odor should not be objectionable, and no residual odor can be left after it evaporates from the clothes.

Petroleum solvents used by the paint industry must also pass rigid specifications and contain no materials that could discolor the pigments. If solvents are used in interior paints, their odor is important and they should be free of aromatic hydrocarbons.

Solvents used in printing inks must evaporate rapidly, as otherwise the pages of the newspapers and other printed materials will smear. Solvents used by other industries may be required to have a certain solvent power towards the materials that they must dissolve. Such solvents should contain aromatic hydrocarbons. Specifications for the aromatic hydrocarbons, like benzene or toluene, produced from petroleum are essentially the same as those for the same hydrocarbons obtained from other sources. Nature makes no differentiation between the pure chemical compounds produced from different sources. For instance, alcohol produced from petroleum is exactly the same as the alcohol made from potatoes, molasses or grains.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

REFINING ENGINEER'S

Construction Survey

Who's Building What in Refining

A New Department, To Keep You Abreast of Construction Developments.

Keeping in touch with new developments, new construction, the expansion of the refining and allied industries is one of the most important activities for the whole industry. As construction goes, so goes the industry; the index of building is a barometer of the 'weather' for refining, a yardstick to show how the industry is growing. Given a good backlog of building contracts, the industry is actually or potentially prosperous, even though much of the money being spent may be 'borrowed.'

Competition as of now and in very recent years has induced the industry to expand rapidly its catalytic facilities, cracking, reforming, alkylation, polymerization, even isomerization is coming again into the picture. Octane ratings have risen remarkably, being at once the cause and the effect of increasing compression ratios in many new automotive engines. One of the major problems being solved is that of: Whether or not they shall make and market two, three or up to five grades of gasoline, to meet the requirements of the various engine compression ratio brackets on the road, of various vintages and power levels. All this calls for careful evaluation of the individual refiner's facilities.

Each prophecy of future petrochemical demands during recent years has proved to be too low when the date came round. Consumption and thus demand for polyolefins has increased more rapidly than the best informed executives could foresee a year or a few years earlier. New organic chemicals of every conceivable type have been introduced recently. The variety is legion, and the quantities in some cases bid fair to become astronomic in short order, especially in insecticides, plastics and coatings.

This installment of the construction survey is fairly complete, but will become more comprehensive in succeeding issues. Many companies decline to make public their building cost figures, so that no dependable overall expenditure total for the industry can be made with any creditable degree of accuracy; extrapolations to obtain such estimates leave much to be desired. Corrections and additions from readers and the industry in general are invited.

This survey will be published in THE REFINING ENGINEER at intervals that will be established in the light of the trend of construction in the industry. Be sure to watch for this report, which will be the most complete and up-to-date survey available to the industry by which it will keep in touch with the most recent developments in construction of new facilities by the refining, gas processing and petrochemical industries both at home and abroad.

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
Girdler Corp.	Girdler Corp.	Moundsville, W. Va.	Allied Chemical & Dye Corp;	Vinyl Chloride, Hydrogen, Carbon Monoxide	.....	.....	.....
Foster Wheeler Corp.	.....	Grand Junction, Colo.	American Gilsonite Co.	Delayed Coker	4000 B/D Feed	$5,000,000+	Spring 1957
H. K. Ferguson	California Research Corp.	Grand Junction, Colo.	American Gilsonite Co.	Cat Reformer	1750 B/D Feed	.....	Spring 1957
H. K. Ferguson	Girdler Corp.	Grand Junction, Colo.	American Gilsonite Co.	Hydrogen Unit	550,000 cf/D production	.....	Spring 1957
Kaiser Engineers	.....	Grand Junction, Colo.	American Gilsonite Co.	Coke Calciner	250 T/D calcined coke production	.....	Spring 1957
M. W. Kellogg, Lummus Co., Ralph Parsons	Same	Yorktown, Va.	American Oil Co.	Refinery	35,000 B/D	$125,000,000	Late 1956
Contract not let	.....	Texas City, Tex.	American Oil Co.	Ultraformer	21,000 B/D	.....	Late 1957
Procon, Inc.	Same	Cyril, Okla.	Anderson-Prichard Oil Corp.	Cat Cracker	5000 B/D	.....	March 1957
.....	.....	Catlettsburg, Ky.	Ashland O. & R. Co.	Crude Unit	20,000 B/D	.....	Fall 1956
				Cat Cracker	25,000 B/D	.....	
				Cat Cracker Expansion	10,000 B/D	.....	
Blaw-Knox Co.	Same	Philadelphia, Pa.	Atlantic Ref. Co.	Catformer Unit	15,000 B/D	.....	Mid 1957
Blaw-Knox Co.	Same	Atreco, Tex.	Atlantic Ref. Co.	Unifiner	15,000 B/D	.....	Mid 1957
				Catformer Unit	15,000 B/D	.....	Mid 1957
Contract not let (Aug. 8, 1956)	.....	Crane, West Tex.	Atlantic Ref. Co. Phillips Petr. Co. Continental Oil Co. Chicago Corp.	Unifiner	15,000 B/D	.....	Mid 1957
				Natural Gasoline Plant	25,000,000 cf/D	.....	Late 1956
.....	.....	Muskegon, Mich.	Aurora Gasoline Co.	Fluid Cat Cracker	7000 B/D	.....	Early 1957
				Exp. Vac. Unit	6500 B/D	.....	End 1956
				Cat Poly. unit	1000 B/D	.....	Feb. 1957
Procon Inc.	Same	Detroit, Mich.	Aurora Gasoline Co.	UOP Reforming	5500 B/D	$3,000,000	Completed
				Fluid Coker	4000 B/D	.....	Fall 1956
Fluor Corp.	Same	Bakersfield, Calif.	Bankline Oil Co.	Cat Reformer	4000 B/D		
				Coker	4000 B/D	$3,000,000	Fall 1956
				Alkylation	1500 B/D		
Bechtel Corp.	Calif. Oil	Perth Amboy, N. J.	Calif. Oil Co.	Cat Reformer (Platformer)	13,000 B/D	$1,000,000	Nov. 1956
.....	.....	Bishop, Tex.	Celanese Corp.	Expansion	25 per cent formaldehyde, acetaldehyde, methanol, etc.	.....	1957 .....
.....	.....	New Orleans, La.	Chemoil Corp.	Refinery	20,000 B/D	$20,000,000	1957
Delta Engineering Co.		Roberts Ranch, Midland County, West, Tex.	Cities Service Oil Co. (Del) and others	Natural Gasoline Plant	50,000,000 cf/D	.....	Mid 1957
.....	.....	Ponca City, Okla.	Cities Service Oil Co. (Del.)	Hexformer	6000 B/D	.....	First 1957
				Exp. Fluid Cat	5000 B/D	.....	Spring 1957
				Crude Unit	12,000 B/D	.....	Spring 1957
				Vac. Dist.	4000 B/D	.....	Spring 1957
.....	.....	Chicago, Ill.	Clark O. & R. Co.	Cat Cracker	15,000 B/D	.....	Spring 1957
				Alkylation, Vac. Dist.	.....	.....	.....
Construction contractor not yet selected	Owner	Terre Haute, Ind.	Commerical Solvents Corp.	Expansion of Chem. Derivatives	.....	$2,000,000	June 1957
Construction by Ford, Bacon and Davis Constr. Corp.	Owner	Sterlington, La.	Commercial Solvents Corp.	Expansion of Ammonium Nitrate	.....	$3,000,000	Dec. 1956
Construction by Ford, Bacon and Davis Constr. Corp.	Owner and Ford, Bacon and Davis Constr. Corp.	Sterlington, La.	Commercial Solvents Corp.	Expansion of Synthetic Methanol	.....	$4,000,000	June 1957
.....	.....	.....	Continental Oil Co.	T. C. C. Exp.	7000	.....	Sept. 1956
M. W. Kellogg Co.	Same	Ponca City, Okla.	Continental Oil Co.	Cat Reformer	11,000 B/D	$3,300,000	Mid 1957
.....	.....	Corpus Christi, Tex.	Corpus Christi Refining Co.	General Rebuilding	7000 B/D	$1,200,000	1956
Badger Mfg. Co.	Same	Big Spring, Tex.	Cosden Pet. Corp.	Styrene Unit	20,000,000 lb/Yr.	$3,000,000	Late 1957
				Unifining Unit	2100 B/D		
.....	.....	Corpus Christi, Tex.	Delhi-Taylor	Platformer-Unifiner	1400 B/D	.....	May 1957
.....	.....	Memphis, Tenn.	Delta Ref. Co.	Crude exp.	8000 B/D	.....	Late 1956
				Platformer	2005 B/D	.....	
Staff	Litwin Eng.	Wichita, Kans.	Derby Ref. Co.	Hydrodesul.	2500 B/D	.....	Spring 1957
				Crude Increases			
				Ultraformer	2500 B/D	.....	.....
.....	.....	Bakersfield, Calif.	Douglas Oil Co.	Unifiner	1500 B/D	.....	Late 1956
.....	.....	Bay City, Mich.	Dow Chemical Co.	Ethylene, etc.	.....	.....	Late 1957
Tellepsen Petro-Chem Constr.	Dow and C. F. Braun Co.	Velasco, Tex.	Dow Chemical Co.	Synthetic Glycerine Plant	Expansion	.....	Spring 1957
The Barton-Malow Co.	Dow	Ironton, Ohio	Dow Chemical Co.	Polystyrene Plant	.....	.....	Late 1956
Tellepsen Petro-Chem Constr.	Dow	Freeport, Tex.	Dow Chemical Co.	Ethylene Oxide Plant	15,000 T/Yr.	.....	Late 1956
.....	.....	Duncan, Okla.	D-X Sunray Oil Co.	Hydrogenation	11,000 B/D	.....	Late 1957
				Cat Reformer Exp.	3,500 B/D	.....	Late 1957
				Treating Unit	8000 B/D	.....	Late 1957
.....	.....	Tulsa, Okla.	D-X Sunray Oil Co.	Cat Reformer	12,000 B/D	.....	Early 1957
				Hydrogenation	12,000 B/D	.....	
				Alkylation	2500 B/D	.....	
				Isomerization	1500 B/D	.....	
Scientific Design Co.	Same	Passaic, N. J.	Electrons Chem. Corp.	Polyvinyl Chloride	.....	.....	Late 1956
.....	Universal Oil Products Co.	Four Corners Area, N. M.	El Paso Natural Gasoline Prod. Co.	Refinery	.....	.....	Fall 1957
Fluor Corp.	Same	Odessa, Tex.	El Paso Natural Gas Co., Gen. Tire & Rubber Co.	GR-S Rubber	40,000 T/Yr	$20,000,000	July 1957
Fluor Corp., Ltd.	Fluor Corp. Ltd.	Odessa, Tex.	El Paso Natural Gas Prod. Co., and others	Butadiene	50,000 T/Yr.	$22,000,000	Mid 1957
.....	.....	Denver, Colo.	Empire Pet. Co.	Hydrodesulfurizer Unit	1000 B/D	.....	Winter 1956
Blaw-Knox	.....	Pensacola, Fla.	Escambia Bay Chem. Corp.	PVC Resin	30,000,000 lb/Yr Nominal Design	.....	Dec. 1, 1956
.....	.....	Baton Rouge, La.	Esso Standard Oil Co.	X-Ray Unit Computer Unit	.....	$1,500,000	Mid 1956
.....	.....	Bayonne, N. J.	Esso Standard Oil Co.	MEK Expansion and Dewaxing	.....	.....	.....
.....	.....	Linden, N. J.	Esso Standard Oil Co.	Ethylene Unit	.....	$12,000,000	1956
.....	.....	Baton Rouge, La.	Esso Standard Oil Co.	Ethylene Unit	.....	.....	1956
.....	.....	Linden, N. J.	Esso Standard Oil Co.	Powerformer	20,000 B/D	.....	1956
				Hudroformer	20,000 B/D		
				Alkylation	7500 B/D		Early 1957
.....	.....	Everett, Mass.	Esso Standard Oil Co.	Powerformer	7200 B/D	.....	Mid 1957
.....	.....	Baton Rouge, La.	Esso Standard Oil Co.	Powerformer	20,000 B/D	.....	1957

IT'S A LONG, LONG WAY...

FROM HERE

TO HERE!

Geographically, from the source of crude to the ultimate application of the final refinery product may be half a world . . . or only a few miles. 10 miles or 10,000 miles, you can be sure that the finished product has come a long, long way.

The demand for better motor fuels created by the continuing improvement of the modern automotive engine is a constant challenge to the refining industry to keep this road from reaching impractical or impossible lengths.

For over 40 years, the research and engineering staffs at Universal have been helping refiners meet this challenge by consistently developing, and making available to the entire industry, improved processes for producing products from petroleum.

No matter the brand name of the finished product, chances are its journey from well to gas tank was helped along by one or more UOP processes. Refiners, all around the world, are using them to provide better products, more efficiently and with significant economy.

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD,
DES PLAINES, ILLINOIS, U. S. A.

Forty Years of Leadership In Petroleum Refining Technology

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
Catalytic Constr. Co.	Same	Baton Rouge, La.	Ethyl Corp.	Vinyl Chloride	.....	.....	Late 1957
Catalytic Constr. Co.	Houdry	Orange, Tex.	Firestone Tire & Rubber Co.	Dehydrogenation	40,000 T/Yr Butadiene	.....	Early 1957
				Styrene	70,000 T/Yr	.....	Early 1958
		Ft. Pierce, Fla.	Frontier Ref. Co.	Refinery	.....	.....	.....
Blaw-Knox	Same	Tonawanda, N. Y.	Frontier Oil Refining Co.	Cat Reformer	6000 B/D	$2,000,000	Late 1956
		No. Tonawanda,	Frontier Oil	Hydrodesulf.	8000 B/D		Late 1956
Scientific Design, Inc.	Same	Linden, N. J.	General Aniline & Film	Ethyl Oxide, Glycol	.....	$8,000,000	1957
Bechtel Corp.	Socony and Bechtel	Ferndale, Wash.	General Petroleum Corp.	Sovaformer, etc.	9000 B/D	Part of $9,000,000	1956
		Lake Charles, La.	General Petr. Corp.	Ammonia	100,000 T/Yr	$12,005,000	Late 1957
Girdler	Same	Avon Lake, Ohio	B. F. Goodrich Chemical Co.	Polyvinyl Resin	.....	$5,000,000	March 1957
		Institute, W. Va.	Goodrich-Gulf Chemicals, Inc.	Rubber Plant	Modernization		1957
Not Selected	Karglien & Hughes, & Goodyear	Akron, Ohio	Goodyear Synthetic Rubber Corp.	GR-S Latex	.....	$2,400,000	May 1957
Fluor Corp.		Baton Rouge, La.	Grace Chemical Co.	Polyethylene	25,000 T/Yr	$18,000,000	Mid 1957
Delta Engineering Co.	Same	Cyddo Parish, La.	Gulf Nat. Gas.	Gasoline Plant	20,000,000 cf/D		Spring 1957
Procon, Inc.	Same	Philadelphia, Pa.	Gulf Oil Corp.	Platformer	20,000 B/D	.....	1956
Ralph M. Parsons Co.	Same	Philadelphia, Pa.	Gulf Oil Corp.	HF[3] Alkylation	3000 B/D	.....	1957
M. W. Kellogg Co.	Same	Philadelphia, Pa.	Gulf Oil Corp.	(2) Gulfining Units	20,000 B/D Each	.....	1957
Catalytic Construction Corp.	Same	Philadelphia, Pa.	Gulf Oil Corp.	Vis Breaker	22,500 B/D	.....	1957
		Philadelphia, Pa.	Gulf Oil Corp.	Storage Cap.	720,000 Bbl.	.....	1957
Procon, Inc.	Universal Oil Products Co.	Philadelphia, Pa.	Gulf Oil Corp.	Cat Reformer No. 2	26,000 B/D	.....	
				Cooling Tower	Doubled	.....	
				Steam Unit	400,000 lb/hr	.....	Late 1957
				Tankage	1,000,000 bbl	.....	
Ralph M. Parsons Co.,	.....	Port Arthur, Tex.	Gulf Oil Corp.	Sulfur increase	70 to 140 T/D	.....	
Leonard Construction Co.	.....	.....	.....	Acid Recovery	.....	.....	
Procon, Inc.	.....	.....	.....	Cat Poly	2360 to 3000 B/D	.....	Fall 1957
M. W. Kellogg	.....	.....	.....	Alkylation	1200 to 4000 B/D	.....	
.....	Universal Oil Products Co.	Port Arthur, Tex.	Gulf Oil Corp.	Platforming Unit	26,000 B/D	.....	Early 1958
.....	.....	Signal Hill,Calif.	Hancock Oil Co.	Expansion of:	.....	.....	.....
				Cat Cracker	2000 B/D		End 1956
				Vac. Unit	15,000 B/D		
				Crude Unit	7000 B/D		
				Visbreaker	3500 B/D		
Ralph M. Parsons Co.	Same	Signal Hill, Calif.	Hancock Oil Co.	Fluid Coker	6000 B/D	$2,000,000	Mid-1957
		Parlin, N. J.	Hercules Powder Co.	Polyethylene	15,000 T/Yr	$10,000,000	1957
Vulcan C. & S. Co.	Same	Louisiana, Mo.	Hercules Powder Co.	Methanol	7,000,000 Gal/Yr	$2,000,000	Mid-1957
.....	.....	Fords, N. J.	Heyden Chem. Co.	Penta-Erythritol	12,000 T/Yr	.....	Spring 1957
.....	.....	Prentice Field Yoakum Co., Tex.	Honolulu Oil Co. (19 others)	Nat. Gaso. Plant	12,000,000 cf/D	.....	Early 1975
.....	.....	Baytown, Texas	Humble O. & R.	Fluid Cat Cracker	55,000 B/D	$27,000,000	1957
.....	.....	Baytown, Tex.	Humble Oil & Refining Co	Butadiene	Add 16,000 T/Yr	.....	Late 1956
Southwestern Engineering Co.	Same	Mount Vernon, Indiana	Indiana Farm Bureau Coop. Assn., Inc.	Platformer	3000 B/D	$1,250,000	Sept. 1956
				Unifiner	2,100 B/D		
		Wrenshall, Minn.	Internat. Refs.	Powerformer	3000 B/D	.....	.....
C. F. Braun Co.	Same	Cushing, Okla.	Kerr-McGee Oil Industries, Inc.	Modernization	.....	.....	.....
Koppers Co.	Ziegler-Koppers	Middlesex Co., N. J.	Koppers Co.	Polyethylene	15,000 T/Yr		1956
Koppers Construction Div.	Same	Los Angeles, Cal. Area	Koppers-Brea Chemicals, Inc.	Polyethylene	60,000,000 lb/Yr	$10,000,000	Mid-1957
Bechtel	Magnolia-Bechtel	Beaumont, Tex.	Magnolia Petr. Co.	Adding Crude Capacity	15,800 B/D	.....	Late 1956
Bechtel	Socony-Mobil	Beaumont, Tex.	Magnolia Petr. Co.	TCC Unit	27,800 B/D	.....	Early 1957
Bechtel	Socony-Mobil	Beaumont, Tex.	Magnolia Petr. Co.	Sovaformer	20,000 B/D	.....	Late 1956
.....	.....	Beaumont, Tex.	Magnolia Petr. Co.	Sovafiner	30,000 B/D	.....	Late 1957
.....	.....	Beaumont, Tex.	Magnolia Petr. Co.	Sulfuric Alkylation Unit	8000 B/D	.....	Late 1957
Refinery Engineering	Same and UOP	McPherson, Kansas	Natl. Cooperative Refinery Assn.	Alkylation	1500 B/D	$1,500,000	Oct. 1956
.....	.....	Bellingham, Wash.	New England, Industries, Inc.	Refinery	.....	$18,000,000	1957
.....	.....	St. Paul Park, Minn.	No-Western Ref. Co.	Cat Reformer	6000 B/D	.....	Early 1957
Sam W. Emerson Co.	Wilbur Watson Associates	Robinson, Ill.	Ohio Oil Co.	Control Lab	.....	.....	Dec. 1956
.....	.....	Tulsa, Okla.	Ozark-Mahoning Co.	Ammonium Phosphate	50,000 T/Yr	.....	Early 1957
The Lummus Co.	Same & Staff	El Dorado, Ark.	Pan-Am Southern	Ultraformer	6200 B/D	.....	Mid-1957
		Wichita Falls, Texas	Panhandle Oil Corp.	Platformer	.....	$750,000	Late 1956
Dresser Engineering Co.	Same	Fort Stockton, Texas	Permian Basin Pipeline Co.	CO^2 Removal Plant	Increase capacity 80MMCFD	$7,000,000	Jan., 1957
Fluor Corp.	Same	Lake Charles, La.	Petroleum Chemicals Inc.	Butadiene Expansion	From 65,500 to 79,000 T/Yr.	$4,354,000	Nov. 1956
		Lake Charles, La.	Petroleum Chemicals, Inc.	Ammonia Unit	100,000 T/Yr.	$1,250,000	Fall 1957
Fluor Corp.	Same	Lake Charles, La.	Petroleum Chemicals, Inc.	Coker	10,000 B/D	$6,250,000	1957
.....	.....	Flat Rock, Mich.	Petroleum Specialties, Inc.	Platformer Exp.	600 B/D	.....	Late 1956
				Thermal Crack			Late 1956
				Thermal Reform.			Late 1956
Bechtel	Same	Houston, Tex.	Petro-Tex. Chemical	Butadiene Exp.	80,000 short tons	$1,000,000	Late 1956
.....	.....	Andrews Co., West Tex.	Phillips Chem. Co.	Sulfur Plant	60 long T/D	.....	Late 1956
.....	.....	Borger, Tex.	Phillips Chem. Co.	Synth. Rubber	Up to 30,000 T	.....	Mid 1957
				Butadiene Expansion	Up to 24,000 T		
Badger Div.	Same	Sweeny, Tex.	Phillips Chem. Co.	Ethylene	165 T/D	$12,000,000	Spring 1957
Badger Div.	Same	Sweeny, Tex.	Phillips Chem. Co.	Butadiene	90 T/D	.....	Mid 1957
Fish Eng.	Same	Kennewick, Wash.	Phillips Pacific Chem. Co.	Ammonia Plant	200 T/D	$12,000,000	Late 1956
.....	.....	Borger' Tex.	Phillips Petroleum Co.	Crude Unit	.....		
				Cat Cracking			
				Alkylation		$15,600,000	1957
				Hydrogenation, Etc.			
.....	.....	Kansas City, Kansas	Phillips Petroleum Co.	Isomerization Unit	.....	$6,000,000+	1957
.....	.....	Sweeny, Tex.	Phillips Petroleum Co.	Alkylation	8000 B/D		1957
				Isomerization	6000 B/D	$23,000,000	1957
				Cat Cracker, Etc.			

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
.....	.....	Houston, Tex. Area	Phillips Petroleum Co.	Furnace carbon black plant	32,000 T/Yr	.....	1958
.....	.....	Hattiesburg, Miss.	Pontiac Eastern Ref. Co.	Refinery	15,000 B/D	.....	Spring, 1957
.....	.....	Longview, Tex.	Premier Oil Co.	Platformer Unifiner	.....	$1,280,000	1957
Girdler	Girdler	Chicago, Ill.	Procter and Gamble Mfg. Co.	Hydrogen Plant	.....	.....	Sept. 1956
Girdler	Girdler	Kansas City, Kans.	Procter and Gamble Mfg. Co.	Hydrogen Plant	.....	.....	Spring 1957
M. W. Kellogg Co.	Same	Lemont, Ill.	Pure Oil Co.	Cat Reformer Feed Prep. Unit	12,000 B/D 17,000 B/D	.....	Mid-1957
Macco	Same	Wilmington, Calif.	Richfield Oil Corp.	Water Treater Amine Regen.	.....	$500,000	Late 1956
Foster Wheeler Corp.	Same	Houston, Tex.	Rohm & Haas	Methanol	100 T/D	.....	Early 1957
C. F. Braun	Same	Santa Fe Spr., Calif.	Rothschild Oil	Cat Cracker	6000 B/D	$2,000,000	Early 1957
Company Staff	Same	Salt Lake City, Utah	Salt Lake Ref. Co.	Crude Capacity added	3000 B/D	.....	.....
To be selected	To be selected	Salt Lake City	Salt Lake Ref. Co.	Cat Reformer	6000 B/D	.....	Sept. 1957
Fluor Corp. & C. F. Braun Co.	Same	Norco, La.	Shell Chem. Corp.	Hydrogen Peroxide	.....	.....	Spring 1957
Fluor Corp. (Offsite Constr.)	Same & Staff	Norco, La.	Shell Chem. Corp.	MEK Unit	40,000,000 lb/Yr	.....	1957
C. F. Braun (Unit Constr.)	Same & Staff	Torrance, Calif.	Shell Chem. Corp.	Butadiene, Styrene Copolymer Units	110,000 long tons	.....	Fall 1958
M. W. Kellogg Co.	Same	Ventura, Calif.	Shell Chem. Corp.	Synth. Urea	.....	.....	Fall 1956
.....	.....	Martenez, Calif.	Shell Oil Co.	Asphalt Plant.	1500 B/D	.....	March 1957
.....	.....	Wood River, Ill.	Shell Oil Co.	Platformer	20,000 B/D	.....	Nov. 1956
Hudson Engineering Corp.	Same	Healdton, Okla.	Signal Oil & Gas Co.	Natural Gaso. Absorption	70,000,000 cf	$1,200,000	Sept. 1956
.....	.....	East Chicago, Ill.	Sinclair Ref.	Hydrofinishing Lubricants	.....	$1,200,000	1956
.....	.....	Wood River, Ill.	Sinclair Ref.	Cat Reformer	7500 B/D	.....	Mid 1957
Company	Litwin Engr. Co. Litwin Engr. Co.	Newcastle Wyo.	Sioux Oil Co.	C_3-C_4 Recovery Unit	180 B/D	$55,000	Oct. 1956
Stearns-Roger Fluor Corp.	Skelly Staff Same	Denver, Colo. East St. Louis, Ill.	Skelly Oil Co. Socony Mobil Oil Co., Inc.	Platformer Sovaformer Sovafiner	1000 B/D 12,000 B/D 16,000 B/D	$4,750,000	Mid 1956 Early 1957
Bechtel	Same	Brooklyn	Socony Mobil	Sovaformer	9000 B/D	.....	Fall 1956
Foster Wheeler Corp.	Same	Paulsboro, N. J.	Socony Mobil Oil Co., Inc.	Hydrodesulfuriser	22,000 B/D	$3,400,000	Early 1957
Girdler	Girdler	Savannah, Ga.	Southern Nitrogen	Ammonia-Nitrate Acid-Nitrogen Solutions — Ammonium Nitrate-Urea	250 Tons of NH^3	$14,000,000	Late 1956
.....	.....	Tampa, Fla.	Southland Oil Co.	Crude Unit Cat Cracker Cat Reformer Alkylation	15,000 B/D	$10,000,000	1957
.....	Staff	San Antonio, Tex.	Southwest Research Institute	Nuclear Research Unit	.....	$750,000	Early 1957
Fluor Corp.	Same	El Segundo, Calif.	Standard Oil Co. (Calif.)	Crude Handling Facilities	.....	$3,000,000	.....
M. W. Kellogg Co.	Same	Richmond, Calif.	Standard Oil Co. (Calif.)	Ammonia Nitric Acid	200 T/D 230 T/D	$13,000,000 (All)	Fall 1956
Fluor Corp.	Standard Oil	Richmond, Calif.	Standard Oil Co. (Calif.)	Benzoic-Toluic Recovery Unit	.....	.....	Nov. 1956
.....	.....	Hawaii	Standard Oil Co. (Calif.)	Refinery	25,000 B/D	$30,000,000	Late 1957
Foster Wheeler Corp.	Same	Casper, Wyo.	Standard Oil Co. (Ind.)	Furfural Unit Vacuum Unit Dewaxing, Deoiling Lube Unit Propane Deasphalting	1500 B/D 5000 B/D 2000 B/D 5000 B/D 1000 B/D	.....	Mid-1957 Mid-1957 Mid-1957 Mid-1957
.....	.....	Whiting, Ind.	Standard Oil Co. (Ind.)	Ultraformer Urea Lube Dewax Unit	21,000 B/D 10,000,000 Gal/Yr.	.....	Early 1957 1957
.....	.....	Sugar Creek, Mo.	Standard Oil Co. (Ind.)	Alkylation	4000 B/D	.....	Spring 1957
.....	.....	Cleveland, Ohio No. 1	Standard Oil Co. (Ohio)	Alkylation	.....	$3,700,000	Spring 1958
M. W. Kellogg	Same	Toledo, O.	Standard Oil Co. (Ohio)	Modernization	.....	$15-40,000,000	1957-8
.....	.....	El Paso, Tex.	Standard Oil Co. (Tex.)	Crude Unit	25,000 B/D	.....	Late 1956
Stauffer Research Dept. & Singmaster & Bryer	Ralph M. Parsons	Louisville, Ky.	Stauffer Chem. Co.	Carbon Tet- Perchlorethylene Chloroform Methylene Chloride Hydrogen-chloride	.....	.....	June 1957
.....	.....	Tacoma, Wash. Area	Straits, Ref. Co.	Refinery	10,000 B/D	$26,400,000	1957
Nason & Cullen	Sun Oil Co.	Marcus Hook, Pa. Unit #2	Sun Oil Co.	Research & Development Laboratory	.....	$1,000,000	Aug. 1957
Lathrop & Sons	Sun Oil Co.	Toledo, Ohio	Sun Oil Co.	Medical Dept. & Gatehouse	.....	$600,000	Nov. 1956
Refinery Engineering Co.	U. O. P.	Corpus Christi, Texas	Suntide Ref. Co.	Unifiner Rexformer Udex Extraction H. F. Alkylation	6000 B/D 15,000 B/D 7500 B/D 1000 B/D	$5,000,000	May 1957
Vogt GATX	Vogt GATX	Corpus Christi, Tex. Corpus Christi, Tex.	Suntide Ref. Co. Suntide Ref. Co.	(2) HP Boilers Tanks (8) (2) (2) (2)	75,000 lb/hr. ea 200,000 Bbl 10,000 Bbl 15,000 Bbl 25,000 Bbl	$280,000 $2,250,000	Dec. 1956 Jan. 1958
Suntide	Suntide	Corpus Christi, Tex.	Suntide Ref. Co.	Polymerization Deethanizer Unit	800 B/D	$30,000	Sept. 1956
Suntide Suntide Fluor Corp.	Suntide Suntide Fluor Corp.	Corpus Christi, Tex. Corpus Christi, Tex. Houston, Tex.	Suntide Ref. Co. Suntide Ref. Co. Texas Butadiene & Chemical	Mineral Spirits Misc. piping Dehydrogentation; furfural extraction; sulfuric acid alkylation	200 B/D ..... 65,000 T butadiene per year; 2,500,000 Bbl/Yr	$80,000 $500,000 $30,000,000	Sept. 1956 May 1957 Late 1956
Company Staff	Same	Baker, Mont.	Texas Natural Gaso. Corp.	Nat. Gaso. Plt.	80,000 Gal/D	.....	Nov. 1956
Refinery Engineering Refinery Engineering Refinery Engineering	Same Same Same	Eagle Point, N. J. Eagle Point, N. J. Westville, N. J.	The Texas Co. The Texas Co. The Texas Co.	Hydrotreater Visbreaker Hydrotreater, Visbreaker	6500 B/D 13,000 B/D 6500 B/D 13,330 B/D	$1,250,000 $1,250,000	Sept. 1956 Oct. 1956 Late 1956

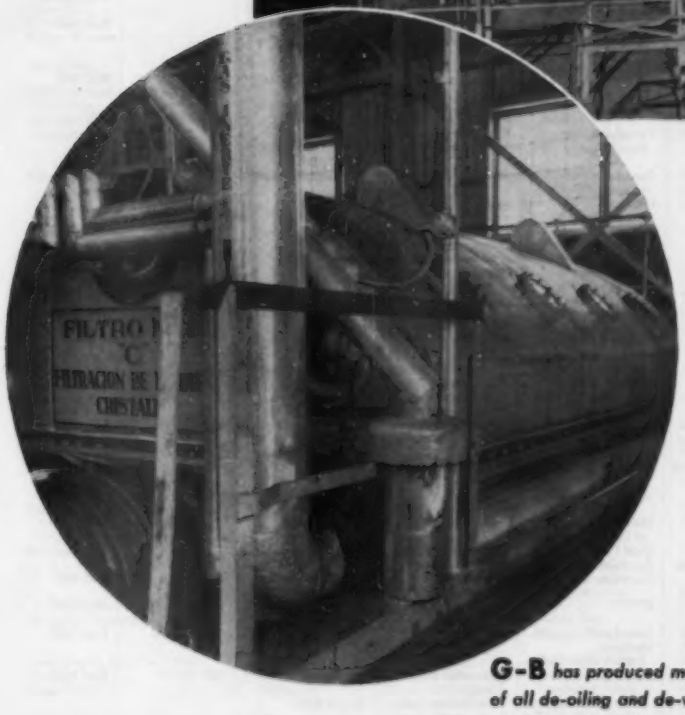
CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
The Texas Co. and others	The Texas Co.	Wilmington, Calif.	The Texas Co.	Butane Deasphalter	13,000 B/D	.....	Fall 1956
The Texas Co. and others	The Texas Co.	Lawrenceville, Ill.	The Texas Co.	Increase Cap. VPS	8500 B/D	.....	Fall 1956
				Fluid Cat Cracker	2000 B/D	.....	Late 1956
O. W. Collins	Stone & Pitts	Port Arthur, Tex.	The Texas Co.	Analytical & Testing Lab.	.....	.....	Fall 1956
Foster Wheeler Corp. and others	Foster Wheeler	Port Arthur, Tex.	The Texas Co.	Stabilizer	.....	.....	Late 1956
The Texas Co. & others	Jackson & Moreland	Port Arthur, Tex.	The Texas Co.	Power Plant	900,000 lb/Hr Steam and 15,000 KWH	.....	Fall 1957
None Selected	None Selected	Port Arthur, Tex.	The Texas Co.	Crude Unit	86,000 B/D	.....	Late 1957
None Selected	None Selected	Port Arthur, Tex.	The Texas Co.	Cat Cracking Unit	60,000 B/D	.....	Late 1957
The Texas Co. & others	The Texas Co.	Port Arthur, Tex.	The Texas Co.	Increase Cap. of Alky. Unit	2000 B/D	.....	Late 1957
None Selected	U. O. P.	Lockport, Ill.	The Texas Co.	Convert Hydro-former to Platformer	10,000 B/D	.....	Fall 1957
Foster Wheeler, C. & I. and others	Foster Wheeler Corp., Chemical & Industrial Corp.	Lockport, Ill.	The Texas Co.	Ammonia and Derivatives Mfg. Facil.	180 T/D	.....	Late 1957
.....	.....	Texas City, Tex.	Texas City Ref. Co.	Cat Reformer	6000 B/D	.....	Mid-1957
Bechtel	Same	Avon, Calif.	Tide Water Assoc.	Fluid Coker	40,000 B/D	.....	Late 1956
				FCC Expan.			
				Desulfurizer	25,000 B/D	.....	Late 1956
Fred Snare Corp.	Same	Delaware City, Delaware	Tide Water Associated	Gas Plant	.....	.....	.....
				Water Front Development			
.....	.....	Wilmington, Del.	Tide Water Associated	Refinery Docks	.....	.....	Mid-1956
.....	.....	Wilmington, Del.	Tide Water Associated	Refinery	130,000 B/D	.....	Late 1956
Fluor Corp.	Same	Eunice, La.	Union Oil & Gas Corp.	Nat. Gaso. Plant	200,000,000 cf/D	.....	June 1957
Koppers Co., Inc.	Koppers Co.	Los Angeles, Calif.	Union Oil Co. of Calif. (Brea Chemicals, Inc., Operator)	Polyethylene	30,000,000 lb/Yr	.....	1957
Procon, Inc.	Same	Warren, Pa.	United Ref. Co.	Fluid Cat Cracker	2500 B/D	$2,000,000	
				Cat Poly Unit	250 B/D		Late 1956
				Treater Unit	.....		
J. B. Gill	Same	Tacoma, Wash.	U. S. Oil & Ref. Co.	Catalytic Cracker	8000 B/D	.....	Dec. 1956
				Topping Unit	.....	.....	
				Vacuum Still	.....	.....	
				Thermal Cracker	.....	.....	
.....	Walter Kidde Constructors Inc.	Baton Rouge, La.	U. S. Rubber Co.	Petrochemicals	60,000,000 lb/Yr	$5,000,000	End 1957
				Pipe Plastics	.....	.....	
Fluor Corp.	John Zink Co.	Salt Lake City, Utah	Utah Oil Ref. Co.	Inert Gas Generator	21,500 cf/hr	.....	1956
Litwin Eng. Co.	Same	Potwin, Kans.	Vickers Pet. Co.	Reformer-Poly.	.....	.....	1957
Western States Ref. Co. and J. C. Hinds	Houdry	Salt Lake City Utah	Western States Refining Co.	Houdriformer	1000 B/D	$330,000	Sept. 1956
Ehrhart & Assoc. Inc.	Same	Huntington Beach, Calif.	Wilshire Oil Co.	Marine Terminal	.....	$1,000,000	1956
So-western Eng. Co.	Same	Norwalk, Calif.	Wilshire Oil Co.	Unifiner-Platformer	10,000 B/D	.....	Early 1957
So-western Eng. Co.	Same	Norwalk, Calif.	Wilshire Oil Co.	Crude Unit	25,000 B/D	.....	Early 1957
				Asphalt Unit	3000 B/D	.....	
				Cat Cracker	7500 B/D		
				Vac. Dist.	15,000 B/D		
Koch Engineering Co.	Same	Sheboygan, Wis.	Wisconsin O.R. Co.	Vac. Still	3000 B/D	.....	1957

FOREIGN CONSTRUCTION

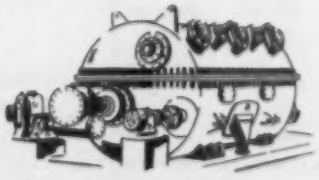
Engineering-Construction Company (Name and Address)	Engineered and Engineered and Designed by (1)	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity (2)	Approximate Cost	Probable Completion Date
.....	.....	Cubatao, Brasil	Alba	Methanol Formaldehyde Synthetic Resins	.....	$2,500,000	1958
Hydrocarbon Research, Inc.	Houdry	Donges, France	Antar-Petroles l'Atlantique	Houdriformer & Udex	13,000 B/D	$10,000,000	March 1957
The Lummus Co.	Same	Ras Tanura, S. Arabia	Arabian American Oil Co.	Hydrofiner	15,000 B/D	$4,000,000	Early 1957
Foster Wheeler Corp.	Same	Bahrain	Bahrain Petr. Co.	Platformer	10,000 B/D	.....	Early 1957
Head Wrightson Processes Ltd.	Same	(Wesste) Manchester, Eng.	Berry Wiggins & Co., Ltd	Refinery Exp.	500 B/D	.....	.....
Head Wrightson Processes Ltd.	Same	(Wesste) Manchester, Eng.	Berry Wiggins & Co., Ltd	Distillation Unit	250 T/D	.....	1957
.....	.....	Sydney, Australia	Bitumens & Oil Refs.	Crude Unit	9000 B/D	.....	1956
.....	.....	Queensland, Australia	Bitumens & Oil Refs.	Platformer	1500 B/D	.....	1957
				Crude Unit	5000 B/D		1957
				Desulfurization	1500 B/D		1957
Kellogg	Same	Clarkson, Ont. Canada	British Amer. Oil Co., Ltd.	Crude Expan.	40,000 B/D	.....	Early 1958
The Lummus Co.	.....	Clarkson, Ont. Canada	British Amer. Oil Co., Ltd.	Cat Reformer	10,000 B/D	$4,000,000	April 1957
Kellogg	.....	Clarkson, Ont. Canada	British Amer. Oil Co., Ltd.	Crude & Vacuum	40,000 B/D	$5,500,000	Sept. 1957
The Lummus Co.	.....	Montreal, Quebec Canada	British Amer. Oil Co., Ltd.	Desulfurization	16,000 B/D	$750,000	Mid-1957
Babcock & Wilcox	.....	Montreal, Quebec Canada	British Amer. Oil Co., Ltd.	CO Boiler & Softener	150,000 lb/hr	$600,000	Early 1957
Middle East & Bechtel Corp. and George Wimpey & Co., Ltd.	M. W. Kellogg Corp.	Aden, Arabia	British Petr. Co.	Thermal Reformer	12,000 B/D	$1,400,000	Early 1958
Richard Costain, Ltd.	.....	Sunbury, Eng.	British Petr. Co.	Analytical & Physics Lab.	.....	$1,200,000	Early 1958
				Production Research Lab.	.....		End 1957

GB BUILDS DE-WAXERS TO FIT *Your* REQUIREMENTS



We are proud to have been a part of the fine record of progress established by the petroleum industry. We were chosen to supply the ten 10′ x 16′ vacuum de-waxing filters used in the Petroleos Mexicanos Refinery. The photographs shown are of this refinery and lube plant. A call to G-B will solve *your* de-waxing and de-oiling problems.

G-B has produced more than 80% of all de-oiling and de-waxing filters used throughout the petroleum industry.



The filter shown on the right is the latest propane pressure de-waxing filter developed for the industry. Call on us for any information or help you may need — at no obligation.

GOSLIN-BIRMINGHAM MANUFACTURING CO., INC.

BIRMINGHAM • ALABAMA

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
Local Contractors	.....	Hamburg, Germany	British Petr. Co.	Increasing Capacity	From 33,000 B/D to 40,000 B/D	.....	End 1957
George Wimpey & Co. and Sir Robert McAlpine & Sons	E. B. Badger & Sons. Kellogg International Corp. (with Universal Oil Products Co.) Power Gas Corp. W. J. Fraser & Co. Rendel, Palmer and Tritton	Isle of Grain, Kent, Eng.	British Petr. Co.	Refinery Expansion	From 4,500,000 T/Yr to 7,000,000 T/Yr	$36,000,000	.....
				Distillation unit	90,000 B/D		
				Cat Reformer	8000-10,000 B/D		
				Thermal Reformer	10,000 B/D		
				(2) Hydrofiners	10,000 B/D each		
				Stabilizer	12,000 B/D		
				(2) solutizers	2000 B/D each		
				(2) copper chloride units	8000 B/D each		
.....	.....	Antwerp, Belgium	British Petroleum Co. and Petrofina	Alkylation Unit	2250 B/D	.....	.....
				Hydrofiner	8000 B/D		
				Cat reformer	7000 B/D		
Head Wrightson Processes, Ltd.	Same	Cardon, Venez.	British Petr. Co.	Gas Plant	1900 tons liquid feed	.....	.....
Head Wrightson Processes, Ltd.	Same	Curacao, Venez.	British Petr. Co.	Gas Plant	1900 tons liquid feed 654 tons gas feed	.....	.....
Head Wrightson Processes, Ltd.	Same	Pernis, Holland	British Petr. Co.	Gas Plant	1900 tons liquid feed 654 tons gas feed	.....	.....
.....	.....	Bombay, India	Burmah-Shell Oil Cos.	SO^2 Unit	6700 B/D	.....	Late 1956
				Cat Reformer			
.....	.....	Sarnia, Ontario Canada	Cabot Carbon Co.	Carbon Black	5,000,000 lb/Yr	.....	Mid-1956
Lummus Co.	Same	Ambes, France	Caltex, S.D.F.	Cat Cracker	4600 B/D	.....	1957
				Vacuum Unit	6300 B/D	.....	1957
Lummus Co.	Foster-Wheeler	Ambes, France	Caltex, S.D.F.	Poly Plant	540 Bbl (Product)	.....	1957
Lummus Co., Ltd.	Lummus, Ltd.	Pernis, Holland	Caltex Petr.	Platformer	7000 B/D	.....	1957
				Desulfurination	4000 B/D	.....	1957
Lummus Co.	Lummus and Staff	Visakhapatnam, India	Caltex Oil Ref.	Refinery	13,500 B/D	.....	Early 1957
Ralph M. Parsons	Same	Alberta, Canada	Canadian-Gulf Oil Co. and British Amer. Oil Company	Sulfur Unit	225 T/D	.....	Fall 1956
Fluor Corp.	U. O. P.	Sarnia, Ont., Canada	Canadian Oil Companies, Ltd.	Petrochemical Plant		$3,000,000	Mid-1957
				Udex Plant	3650 B/D		
				Platforming Unit	4400 B/D		
.....	.....	Montreal E., P.Q., Canada	Canadian Petrofina, Ltd.	Fluid Coking Unit	3600 B/D (Coke Capacity-140 T/D)	.....	.....
.....	.....	Saskatchewan, Can.	Canadian Southern Oils	Refinery	10,000-20,000 B/D	$7,000,000-$10,000,000	.....
.....	.....	West Germany	Chemische Werke Huels A.G.	Synthetic Rubber	30,000 T/Y	$24,000,000	.....
.....	Houdry	Mari, Kreis Recklinghausen, West Germany	Chemische Werke Huels, A.G.	Dehydrogenation (Butadiene)	40,000 T/Yr	.....	.....
Koppers	Same	Cubatao, Brazil	Cia Brasileira de Estireno	Styrene Monomer Plt.	.....	.....	Late 1956
.....	.....	Colombia	Colombian Pet. Co.	Gas Processing Unit	.....	$5,000,000	.....
Lummus Co.	Houdry Process Corp.	Guayanilla Bay, Puerto Rico	Commonwealth Oil Ref. Co., Inc.	Plant Expansion (Crude Combination Unit; Houdry Cracking Plant; Houdry Reforming Unit; Calif. Type Poly Plant; SO^2 Treating Plant)	from 25,000 B/D to 55,000	Not to exceed $40,000,000	Mid-1957
Foster Wheeler	Same	Amuay Bay, Venez.	Creole Petr. Corp.	Pipe Still	70,000 B/D	$10,800,000	.....
.....	.....	Hamburg, Germany	Deutsche Shell A.G.	Cat Reformer	From 20,000 to 56,000 B/D	.....	Mid-1957
				Desulfuriser			
.....	.....	Bremen-Oslebshausen	Deutsche Vacuum Oil	Sovaformer	3200 B/D		
				Sovafiner	4800 B/D	.....	1957
				Sulfur Plt.			
				Distillation			
Catalytic Construction Co.	Same	Sarnia, Ont., Canada	Dow Chemical of Canada, Ltd.	Solvent Amind Unit	.....	$1,000,000	Late 1956
Bechtel	Same	Bombay, India	Dow Chemical Co.	Polystyrene Plant	3000 T/Yr	.....	.....
.....	.....	Assuan Dam, Egypt	Egyptian Govt.	Ammonia Plant	1200 T/D	.....	.....
Lummus Co.	Same	Cairo, Egypt	Egyptian Govt.	Crude Unit	40,000 B/D	$3,000,000	Fall 1956
Brown & Root	Union Carbide & Carbon	Ravenna, Italy	ENICI	Butadiene, etc.	30,000 T/Yr copolymer	$75,000,000	Mid-1957
To be selected	To be selected	Whitegate, Ireland	Esso Petr. Co., Ltd. Shellimex British Petr. Caltex	Refinery	11,200,000 B/Yr	$25,000,000	Late 1959
.....	.....	Fawley, Eng.	Esso Pet. Co., Ltd.	Expansion Program (Crude Oil		$36,400,000	End 1958
				Distillation Unit	70,000 B/D		
				2 auto-diesel hydrofiners			
				Sulphur recovery Plant	2800 T/Yr		
				Jetty Berth Oil and Water Separator Plant			
A. G. McKee Co.	Same	Havana, Cuba	Esso Standard Oil Co.	Hydrofining, Powerforming Cat Cracking Cat Poly Units	From 8500 B/D to 35,000 B/D crude cap.	$30,000,000	1957
.....	.....	Port Jerome, France	Esso Standard Oil Co.	Cat Cracker	10,000 B/D	$10,700,000	Early 1957
.....	.....	San Nicholas, Argentina	Fabrica, Argentina	Phenol Plt	.....	$375,000	1956
.....	.....	Regina, Sask., Canada	Federated Cooperatives Ltd.	Crude Dist. Unit	16,000 B/D	.....	1957-58
				Revamp Thermal Cracking Unit	1000 B/D		1957-58
Head Wrightson Processes	Same	Morwell, Australia	Gas and Fuel Corp. of Australia, Ltd.	Gas Dehydration Plants	36,000 cf/D	.....	.....
Lummus Co., Ltd.	Houdry	Lingen, Germany	Gewerkschaft Erdoel-Raffinerie Emsland	Houdriformer	3500 B/D	.....	.....

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
Tecnider s. p. a.	Same	Gaeta, Italy	GOLFO IP s. p. a.	Topping	15,000 B/D	.....	1957
				Gaso Treating	3000 B/D	.....	1957
				Kerosine Treating	3000 B/D	.....	1957
				Cat Reformer	3000 B/D	.....	1957
Lummus Co.	Same	Guanica, Puerto Rico	Gonzales Chem.	Ammonia	125 T/D	$12,250,000	Late 1956
Hydro.-Krupp	Hydro Res. Inc.	Piraeus, Greece	Greek Govt.	Refinery	30,000 B/D	$15,000,000	Jan. 1957
A. G. McKee Co., Ltd.	B.F. Goodrich and A.G. McKee Co.	Welland, Ont., Canada	B. F. Goodrich Canada, Ltd.	Polyvinyl Chloride	9,000,000 lb/Yr	$3,500,000	Early 1957
.....	.....	Sao Paulo, Brazil	W. R. Grace Co.-Farbwerke Hoechst	Polyethylene	.....	.....	.....
.....	.....	Tokuyama, Japan	Idemitsu Kosan Co.	Refinery	18,000 B/D	$16,000,000	.....
Company Staff	(Texaco License)	Billingsham, Eng.	Imperial Chem. Ind.	Ammonia	200 T/D	.....	.....
.....	.....	Billingsham, Eng.	Imperial Chem. Ind.	Alcohols	40,000 T/Yr	.....	End 1956
E. B. Badger & Sons, Ltd.	Stone & Webster Div., E. B. Badger	Wilton, Eng.	Imperial Chem. Ind.	Chemical Plt.	30 T/D	.....	1956
.....	.....	Wilton, Eng.	Imperial Chem. Ind.	Oil Cracker Ethylene	.....	$48,000,000	Early 1958
Kellogg International	Kellogg and Staff	Wilton, Eng.	Imperial Chem. Ind.	Cracker Exp.	250,000 T/Yr	.....	Fall 1956
Head Wrightson Processes, Ltd.	Same	Wilton, Eng.	Imperial Chem. Ind.	Butadiene Plant	6000-7000 T/Yr	.....	End 1956
.....	.....	Sarnia, Ont., Can.	Imperial Oil	Powerformer	13,500 B/D	.....	1956
.....	.....	Montreal E., P. Q., Can.	Imperial Oil	Powerformer	9000 B/D	.....	1957
.....	.....	Ioco, B. C., Can.	Imperial Oil	Powerformer	5000 B/D	.....	1956
.....	.....	Halifax, N. S., Can.	Imperial Oil	Visbreaker Unit	10,625 B/D	.....	1956
				Thermal Reforming Unit	3100 B/D	.....	1956
				Fluid Cat Cracking Unit	15,200 B/D	.....	1956
				Cat Poly Unit	4000 B/D	.....	1956
				Powerformer	7000 B/D	.....	1956
Fluor Corp.	Same and Co. Staff	Sarnia, Ont., Can.	Imperial Oil	Cat Reformer	13,500 B/D	$7,200,000	Oct. 1956
Fluor Corp. of Canada	Same and Co. Staff	Montreal, P.Q., Can.	Imperial Oil	Hydroformer	8000 B/D	$5,000,000	1956
Fluor Corp.	Imperial Oil	Montreal, P.Q., Can.	Imperial Oil	Cat Reformer	8000 B/D	$4,500,000	Early 1957
Foster Wheeler Corp.	Same	Imperoyal, N. S.	Imperial Oil	LPG Unit	470 B/D	$500,000	Mid 1956
				Hydroformer	7000 B/D	$4,000,000	Late 1956
Ross Anglin	Nenninger & Chenevert	Montreal East, Ont.	Imperial Oil	Maintenance Bldg.	200 x 350 ft	$2,000,000	Late 1956
Brown & Root	Same	Alberta, Can.	Imperial Oil	Nat. Gaso. Unit	10,000,000 cf/D	$3,000,000	Late 1956
Fluor Corp.	Same	Sarnia, Ont. Can.	Imperial Oil	Wax Plant	35,000,000 lb/Yr	$4,500,000	Late 1956
Babcock-Wilcox	Same	Sarnia, Ont. Can.	Imperial Oil	Steam Unit	.....	$500,000	Mid 1956
To be announced	.....	Sarnia, Ont. Can.	Imperial Oil	Detergents	30,000,000 lb/Yr	$25,000,000	1958
				Olefins, Ethylene, Propylene, etc.	10,000 B/D	$25,000,000	1958
Brown & Root	Same	Redwater, Alta., Can.	Imperial Oil	LPG Unit	10,000,000 cf/D	$3,000,000	Late 1956
.....	.....	India	India Govt.	Refinery	30,000 B/D	$40,000,000	1957
.....	.....	Bari, Italy	Industria Petrolifera (STANIO)	Ultraformer	5000 B/D	$2,000,000	Dec. 1956
Bechtel	Same	Cartagena, Colombia	International Petroleum (Colombia) Ltd.	Refinery	26,500 B/D	$32,500,000	Fall 1957
.....	.....	Southhampton, Eng.	Internat. Synth. Rubber	Syn. Rubber	30,000 T/Yr	.....	1957
.....	.....	Palermo, Sicily	ISLOM	Refinery	12,000 B/D	.....	1957
Hydro. Res. Inc.	Same	Chung-Ju, Korea	Korean Govt.	Urea Plant	165 T/D	$25,000,000	.....
E. B. Badger & Sons, Ltd., Bechtel International Corp., G. Wimpey & Co., Ltd.	E. B. Badger & Sons Ltd.	Mina-al Ahmadi, Kuwait	Kuwait Oil Co., Ltd.	Atmospheric Distillation	160,000 B/D	.....	Dec. 1957
Badger Mfg.	Same	Aruba, D.W.I.	Lago Oil	Distillate Cat Treating	20,000 B/D	$3,000,000	1957
The Refinery Engineering Co.	Universal Oil Products Co. and Treco	Edmonton, Alberta, Canada	McCull-Frontenac Oil Co., Ltd.	UOP Platformer	3300 B/D	$900,000	Early 1957
.....	.....	Montreal E., P. Q., Canada	McCull-Frontenac Oil Co., Ltd.	Hydrotreating Unit	10,000 B/D	.....	Late 1957
Fred Snare Corp.	Same	Puerto La Cruz, Venez.	Mene Grande Oil Co.	Port Extension	.....	.....	.....
.....	.....	Stettler, Alta., Can.	Midland Petr. and Pacific Petrochem.	Crude Refinery	4000 B/D	$2,000,000	1957
Stone & Webster Engr. Co.	Scientific Design, Inc.	Iwakuni City, Japan	Mitsui Group	Petrochemicals, Ethylene and Oxide, Cumene, Glycol	.....	$30,000,000	1957
Bechtel	Same	Coryton, Eng.	Mobil Oil Co. Ltd.	Sovaformer	.....	.....	Mid 1956
.....	Badger Div., Stone & Webster	Lavera, France	Naphtachimie	Ethylene Oxide Exp.	.....	$17,800,000	.....
Compagnie de FIVES-LILLE	Lummus Co.	Cienfuegos, Cuba	Natl. Petr. Corp.	Refinery	5000 B/D	$10,000,000	Late 1958
Chemical Construction Co.	Same	Naantali, Finland	Neste Oy	Refinery	18,000 B/D	$17,000,000	April 1957
		Niigata, Japan	Nihon Gas Kagaku Kogyo	Urea	905 T/D	$2,100,000	Early 1957
				Ammonia	100 T/D		Early 1957
				Ammonium Sulfate	200 T/D		Late 1957
Ford, Bacon, and Davis and Kellogg	Commercial Solvents	Medicine Hat, Alberta, Can.	Northwest Nitro Nitro Chemicals, Ltd.	Nitrogen Plt.	.....	$23,000,000	Late 1958
Fluor Corp.	Same	Medicine Hat, Alberta, Can.	Northwest Nitro Chemicals, Ltd.	Phosphoric Acid Plant	.....	.....	.....
Badger Div., Stone & Webster	Same	Pernis, Holland	N. V. Bataafsche	Glycerine	.....	$7,000,000	1957
Chemical Construction Co.	Same	Kudamatsu, Japan	Nippon Petrochemicals, Ltd.	Crude Unit	15,000 B/D	.....	Late 1956
.....	.....	Yokohama, Japan	Nippon Petrochemicals, Ltd.	Crude Unit	20,000 B/D	.....	Late 1956
Badger Division, Stone and Webster	Same	Tokyo, Japan	Nippon Petrochemicals, Ltd.	Isopropyl Alcohol, Acetone	.....	.....	Late 1956
.....	.....	Ft. St. John, B. C. Can.	Pacific Petroleums, Ltd.	Gas Absorption Plant	.....	$18,000,000	.....
.....	.....	Ft. St. John, B. C.	Pacific Petroleums, Ltd.	Sulfur Recovery	100,000 long T/Yr	.....	Fall 1957
Hudson Engineering Co.	Same	Mex. City, Mex.	Pemex	Natural Gaso. Plt.	300,000,000 cf/D	$7,000,000	March 1957
A. G. McKee Co.	Phillips, Esso	Mex. City, Mex.	Pemex	Cat Cracker	16,000 B/D	$12,000,000	Mid 1957
				Poly Unit			
				Alkylation Unit			
				Ethylene, etc.			
A. G. McKee Co.	Same & Phillips	Ciudad, Madero Mex.	Pemex	Cat Creaker	16,000 B/D	$25,000,000	Fall 1957
				Alkylation,	.....		
				Poly Units	.....		
				Topping, etc.	100,000 B/D		
Fluor Corp.	Same & Staff	Minatitlan, Mex.	Pemex	Vacuum Unit	1000 B/D	$4,000,000	Early 1957
A. G. McKee Co.	Same & Staff	Salamanca, Mex.	Pemex	Cat Cracker	12,000 B/D	$4,000,000	
.....	Co. Staff	Posa Rica Mex.	Pemex	Crude Unit	10,000 B/D	$1,500,000	Late 1956

CURRENT CONSTRUCTION IN THE REFINING, NATURAL GASOLINE AND PETROCHEMICAL INDUSTRIES

Engineering-Construction Company (Name and Address)	Engineered and Designed by	Plant or Unit Location	Owner-Operating Company	Type of Plant or Unit	Capacity	Approximate Cost	Probable Completion Date
M. W. Kellogg Co.	Same	Mataripe, Brasil	Petrobras	Revamp	.....	.....	Late 1957
				Thermal Cracker	5000 B/D	.....	
				Lube Unit	3000 B/D	.....	
				Wax Unit	120,000 lb/D	.....	
Foster Wheeler	Same	Cubatao, Brazil	Petrobras	Anhydrous Ammonia	100 T/D	$8,000,000	Late 1956
Hydrocarbon Res. Inc.	Staff	Cubatao, Brazil	Petrobras	Ethylene Recovery	45,000,000 lb/Yr	$1,800,000	Late 1956
Hydrocarbon Res. Inc.	Same	Cubatro, Argentina	Petrobras	Ethylene Unit	15,000 T/Yr	$1,750,000	Late 1956
.....	Compagnia Tecnica Industria Petroli	Partington, Eng.	Petrochemicals, Inc.	Ethylene Oxide, Glycol, Ether Polyglycols	25,000 T/Yr	.....	Late 1956
E. B. Badger	Same	Avonmouth, Eng.	Phillblack	Carbon Black Plt.	85 T/D	.....	1956
Staff	Staff	Sarnia, Ont., Can.	Polymer Corp., Ltd.	Ethylene Plt. Expan.	.....	$2,000,000	1958
Canadian General Electric	Catalytic Constr. Co.	Sarnia, Ont., Can.	Polymer Corp., Ltd.	Plant Expan.	.....	.....	.....
Girdler	Same	Montreal, P.Q. Can.	Quebec Ammonia	Ammonia Nitric Acid	120 T/D	$8,000,000	Mid-1957
Kellogg International Corp.	Kellogg International Corp.	Antwerp, Belg.	Raffinerie Belge de Petroles, S. A.	Catalytic Reformer & Desulfuriser	2500 B/D	$2,000,000	March 1957
Foster Wheeler	Foster Wheeler & U. O. P.	Escombreas, Spain	Rafineria de Petroleos	Platformer	8000 B/D	.....	1957
Foster Wheeler	.....	Escombreas, Spain	Rafineria de Petroleos	Refinery Exp.	60,000 B/D	.....	1957
.....	.....	Genoa, Italy	Raffineria Dott. E. Garrone	Ultraformer	5000 B/D	$2,000,000	Dec. 1956
.....	.....	Augusta, Italy	Raffineria Siciliana Oil Minerali	Ultraformer	5000 B/D	$2,000,000	Dec. 1956
Procon, Inc.	Same	Port Credit, Can.	Regent Ref., Ltd.	Adding Crude Capacity	6000 B/D	.....	Early 1957
				Adding Visbreaker	5000 B/D		Early 1957
				Vacuum Unit	10,000 B/D		Early 1957
				Fluid Cat Cracker	7000 B/D		Early 1957
				Cat Poly Unit	720 B/D		Early 1957
.....	.....	Lavera, France	SF de Petroles BP	Ethylene, Propylene	up to 18,000 T/Yr up to 18,000 T/Yr	.....	.....
Chemical Construction Co.	Same	Shawinigan Falls, P.Q., Canada	Shawinigan Chemicals	Sulfuric Acid	75 T/D	$750,000	Fall 1956
.....	.....	Shell Haven, Eng.	Shell Chem. Co.	Ammonia Plant Fertilizer Plant	75,000 T/Yr	$30,000,000	1957
.....	.....	Philippines	Shell Oil Co.	Refinery	(Proposed)	.....	.....
.....	Marani and Morris	Toronto, Ont., Can.	Shell Oil Co.	Office Bldg.	12 Stories	$4,500,000	Dec. 1956
.....	.....	Montreal E., P. Q., Canada	Shell Oil Co. of Canada Ltd.	Platformer	6000 B/D	.....	Fall 1956
				Hydrodesulfurization Unit	7500 B/D	.....	Fall 1956
				Alkylation	1000 B/D	.....	1957
.....	.....	Montreal East P. Q., Canada	Shell Oil of Canada	M E Ketone, Sec-Butyl Alcohol	5,000,000 lb/Yr	$500,000	Dec. 1956
.....	.....	Montreal East P. Q., Canada	Shell Oil Co. of Canada	Detergent Alkylate Plant	.....	$3,000,000	Mid-1957
Bechtel	Same	Havana, Cuba	Shell Oil Co. of Cuba, Ltd.	Refinery	25,000 B/D	.....	Late 1956
.....	.....	Cardon, Venez.	Shell (Venezuela)	Cat Cracker	33,000 B/D	.....	Fall 1957
.....	.....	Cardon, Venez.	Shell (Venezuela)	Distillation	80,000 B/D	$20,000,000	Mid-1957
				Alkylation	1400 B/D		
Stone & Webster Div. E. B. Badger, Ltd.	.....	Cardon, Venez.	Shell (Venezuela)	Feed Prep.	6,000 B/D	.....	Late 1956
E. B. Badger, Ltd.	Stone & Webster, Badger Div.	Shell Haven, Eng.	Shell Ref. & Market, Inc.	Atmospheric Distillation	80,000 B/D	.....	Mid-1958
.....	.....	Ft. Saskatchewan, Alt., Canada	Sherritt-Gordon Mines, Ltd.	Anhydrous Ammonia(Planned)	75 T/D	$24,000,000	.....
.....	.....	Tokuyama, Jap.	Showa Oil Co.	Ref. Fac.	30,000 B/D	$39,000,000	June 1957
.....	.....	LeHavre, France	Societe du Caoutchoue Butyl	Syn. Rubber Plt.	20,000 T/Yr	.....	Mid-1958
Societe du Caoutchou Butyl (SOCABU)	C. F. Braun	Port Jerome, France	Societe du Caoutchou Butyl	Butyl Rubber Plt.	20,000 T/Yr	$15,000,000	Mid-1958
.....	Foster Wheeler	Lavera, France	Societe Francaise de Petroles BP	Distillation Unit	44,000 to 60,000 B/D	.....	Late 1956
.....	B. P.	Dunkirk	Societe Francaise de Petroles BP	Asphalt Plant	2000 B/D	.....	Late 1956
.....	Kellogg	Dunkirk	Societe Francaise de Petroles BP	Cat Reformer	10,000 B/D	.....	Mid-1958
.....	.....	Marseilles, France	Societe Francaise de Petroles BP	Crude Unit, Etc.	16,000 B/D (nominal)	.....	Late 1957
C. F. Braun Co.	Same and Co. Staff	Bremen, Ger.	Socony Mobil Oil Co., Inc. (Mobil Oil A.G.)	Hydrodesulfurization	6000 B/D	$1,750,000	Early 1957
The Power-Gas Corp., Ltd.	Same	Refinery, Isle of Grain, Kent, Eng.	South Eastern Gas Board	Segas catalytic oil-gas	20,000,000 ct/D	.....	1958
Staff	Staff	Trieste, Italy	SPA Teenico Industriale Aquila	Cat Cracker	3300 B/D	.....	.....
				Cat Poly	1400 B/D		
Foster Wheeler	Hydro. Res. Inc.	Bombay, India	Standard Vacuum	Cat Poly	350 B/D	.....	1958
Stone & Webster Engineering Corp.	.....	.....	Sumitomo Chemical Co., Ltd.	Ethylene Plant	.....	.....	.....
Staff	Hydro. Res. Inc.	Nankong, Formosa	Taiwan Fertilizer Ltd.	Ammonia Plt.	200 T/D Urea	$18,000,000	Spring 1957
Fred Snare Corp.	Same	Santiago, Cuba	The Texas Co.	Steamer Dock	.....	.....	.....
Procon, Inc.	Same	Santiago, Cuba	The Texas Co.	Platformer	3300 B/D	.....	.....
				Hydrotreater	4100 B/D		
				Gaso. Sweetening Crude Unit	.....	.....	.....
.....	.....	Santiago, Cuba	The Texas Co.	Refinery	20,000 B/D	$14,000,000	Early 1957
.....	.....	Ponce, Puerto Rico	Union Carbide Caribe	Ethylene Glycol	.....	$28,500,000	1958
.....	.....	Santos, Brasil	Union Carbide	Polyethylene	.....	.....	.....
Air Products, Inc.	.....	Venezuela	Venezuelan Govt.	Air separation Plt. Hydrogen Purification Plt.	120 T/D Ammonia	$1,000,000	.....
Blaw-Knox	.....	Moron, Venez.	Venezuelan Govt.	Refinery	3000 B/D	$60,000,000	1957
				Chlorine	10,000 T/Yr		
				Caustic Soda	11,200 T/Yr		
				Commercial Explosives	10,000 T/Yr		
				Chemical Fertilizers	150,000 T/Yr		
M. W. Kellogg Co.	Same	Puerto La Cruz Venez.	Venezuelan Gulf	Fluid Cat Cracker	8000 B/D	.....	Late 1956
B. D. Bohna & Co., Ltd. and E. V. Lane Corp.	Koch Engineering Co., Inc.	Dawson Creek, B. C., Canada	X-L Refineries, Ltd.	Houdriformer	500 B/D	.....	.....

DU PONT

PETROLEUM CHEMICALS DIVISION

NEWS

DU PONT

September ★ *One of a Series of Bulletins for the Petroleum Industry* ★ *1956*

Question Box

1. ARE YOU RECEIVING shipment of additives in drums in less than carload lots?
   If so, you will certainly want to read about the four-figure savings you can realize by simply revising your ordering schedule. See article at right.
2. HOW MANY different economy-grade diesel fuel problems can you lick with a single additive?
   In the article below, you may be surprised at how much one additive can accomplish for you.
3. WHO at the Du Pont Petroleum Laboratory can help you make the most efficient use of gasoline additives?
   Read about him on the next page.
4. HAVE YOU called in a doctor recently—for helping your TEL blending personnel maintain their high standards of *safe* living?
   You can find out about this unique Du Pont medical service on the next page.

To help you overcome economy diesel fuel problems

Has the growing demand for economy diesel fuels created new problems for you? Three of the most common problems encountered by refiners are:

1. Incompatibility
2. Instability
3. Sparking tendency

Du Pont Fuel Oil Additive No. 2 (FOA-2) offers you a solution to all three.

It can help you gain the needed refining flexibility by making it possible for you to blend catalytic-cracked stocks with straight-run products, and overcome the incompatibility problem.

Stabilizer and dispersant

In actual railroad service, the stabilizing and dispersant action of FOA-2 has proved highly effective for reducing the tendency of many economy-grade diesel fuels to cause filter-plugging and injector-sticking.

How much can you save by ordering Du Pont additives in tank-car lots?

Refiners can save considerable money by ordering Du Pont additives in tank-car lots. For example, 4,000 gallons delivered in a tank car, rather than in drums in less than carload lots, will save the refiner between $1,680 and $2,400, as shown in this table:

ADDITIVES	GULF COAST		MID-CONTINENT		WEST COAST	
	$ Saving	% Saving	$ Saving	% Saving	$ Saving	% Saving
Du Pont Antioxidant No. 22	$2,250	6.7%	$2,250	6.7%	$2,400	7.0%
Du Pont Fuel Oil Additive No. 2	$1,680	8.3%	$1,710	8.4%	$1,850	8.9%
Du Pont Lube Oil Additives	$1,830	12.0%	$1,860	12.0%	$2,000	12.5%

Because of the difference in freight rates, the actual dollar savings vary according to the location of the refinery receiving shipment. But no matter where your refinery is located, you will find the savings decidedly worthwhile.

How much can YOU save?

To give you the exact figures, one of our nearby representatives

OVER

Locomotive sparking, a problem which is sometimes accentuated with economy fuels, results from the formation of carbon deposits – generally during idling or while coasting downhill. The ejection of these deposits when glowing, and the resulting fire hazard, may occur during runs under heavy load.

A metallic additive is likely to aggravate this situation by increasing the size and cohesiveness of the carbon deposit particles. Field tests show, however, that an *ashless* additive does not contribute to the sparking problem. Rather, it tends to minimize it.

Du Pont FOA-2, therefore, being an *ashless*, nonmetallic additive, can help you reduce any sparking tendency in economy-grade diesel fuels.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

September ★ *One of a Series of Bulletins for the Petroleum Industry* ★ *1956*

Question Box

1. ARE YOU RECEIVING shipment of additives in drums in less than carload lots?
   If so, you will certainly want to read about the four-figure savings you can realize by simply revising your ordering schedule. See article at right.
2. HOW MANY different economy-grade diesel fuel problems can you lick with a single additive?
   In the article below, you may be surprised at how much one additive can accomplish for you.
3. WHO at the Du Pont Petroleum Laboratory can help you make the most efficient use of gasoline additives?
   Read about him on the next page.
4. HAVE YOU called in a doctor recently—for helping your TEL blending personnel maintain their high standards of *safe* living?
   You can find out about this unique Du Pont medical service on the next page.

To help you overcome economy diesel fuel problems

Has the growing demand for economy diesel fuels created new problems for you? Three of the most common problems encountered by refiners are:

1. Incompatibility
2. Instability
3. Sparking tendency

Du Pont Fuel Oil Additive No. 2 (FOA-2) offers you a solution to all three.

It can help you gain the needed refining flexibility by making it possible for you to blend catalytic-cracked stocks with straight-run products, and overcome the incompatibility problem.

Stabilizer and dispersant

In actual railroad service, the stabilizing and dispersant action of FOA-2 has proved highly effective for reducing the tendency of many economy-grade diesel fuels to cause filter-plugging and injector-sticking.

Locomotive sparking, a problem which is sometimes accentuated with economy fuels, results from the formation of carbon deposits – generally during idling or while coasting downhill. The ejection of these deposits when glowing, and the resulting fire hazard, may occur during runs under heavy load.

A metallic additive is likely to aggravate this situation by increasing the size and cohesiveness of the carbon deposit particles. Field tests show, however, that an *ashless* additive does not contribute to the sparking problem. Rather, it tends to minimize it.

Du Pont FOA-2, therefore, being an *ashless*, nonmetallic additive, can help you reduce any sparking tendency in economy-grade diesel fuels.

How much can you save by ordering Du Pont additives in tank-car lots?

Refiners can save considerable money by ordering Du Pont additives in tank-car lots. For example, 4,000 gallons delivered in a tank car, rather than in drums in less than carload lots, will save the refiner between $1,680 and $2,400, as shown in this table:

ADDITIVES	GULF COAST		MID-CONTINENT		WEST COAST	
	$ Saving	% Saving	$ Saving	% Saving	$ Saving	% Saving
Du Pont Antioxidant No. 22	$2,250	6.7%	$2,250	6.7%	$2,400	7.0%
Du Pont Fuel Oil Additive No. 2	$1,680	8.3%	$1,710	8.4%	$1,850	8.9%
Du Pont Lube Oil Additives	$1,830	12.0%	$1,860	12.0%	$2,000	12.5%

Because of the difference in freight rates, the actual dollar savings vary according to the location of the refinery receiving shipment. But no matter where your refinery is located, you will find the savings decidedly worthwhile.

How much can YOU save?

To give you the exact figures, one of our nearby representatives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

For your next project...avail yourself of

PRACTICAL EXPERIENCE

Your industry is increasingly reliant upon process engineering procedures learned far afield. The engineering staff of Stearns-Roger has these resources because of the many areas in which Stearns-Roger is continually engaged: metallurgy, power, atomic energy, chemical processing, and oil and gas processing. These men are ever alert to new designs for more efficient plant arrangement or operation.

Stearns-Roger has for years been closely identified with the oil and gas industry. Processing plants designed and built by Stearns-Roger operate from the extreme cold of Canada to the mild conditions of the Texas Gulf, ranging from the very large to the very small.

Starting with analysis of well-head gas, S-R facilities are complete for handling each successive step through process design, general engineering, fabrication of special equipment in our shops, and field installation with our own personnel. We deliver a completed plant, operating, to meet the customer's long term needs.

TAKE IT UP WITH

Stearns-Roger

THE STEARNS-ROGER MFG. CO. DENVER, COLORADO

DENVER • HOUSTON • EL PASO • SALT LAKE CITY

Stearns-Roger Engineering Company, Ltd., Calgary, Alberta

NEEDED— A New Knock Yardstick?

Research and Motor Octane Numbers not adequate to describe anti-knock performance

C. J. Domke,
N. D. Esau,
D. S. Gray and
H. R. Taliaferro

Research Dept., Standard Oil Company (Indiana)

WILL Research and Motor octane numbers remain adequate to define anti-knock performance in service or will some other methods be required? Early work with a few fuels pointed out that, as compression ratios increase, higher engine knock ratings are assigned to fuels of given Research and Motor octane number.[1] The consequences of increasing sensitivity—the spread between Research and Motor octane number—were later observed with several types of test fuels in 1953 automobiles; however, abnormal spark timing needed to rate high-octane fuels in these automobiles may have affected the relationships between ASTM knock test methods and road ratings.

The trend toward motor fuels of higher anti-knock quality and higher sensitivity has been stressed.[2] This trend showed the need for further study of the anti-knock performance of fuels in high-compression engines. Equally apparent was the need for an experimental technique that did not resort to abnormal ignition timing. Therefore, a wide range of test fuels of differing composition were knock-rated by a technique designed to eliminate the effects of spark advance.

Experimental

To evaluate the influence of increasing octane number, sensitivity, and composition, test fuels made in three groups: olefinic blends of diisobutylene in primary reference fuel, aromatic blends of benzene or toluene in primary reference fuel, and commercial type gasolines. These test fuels covered a range in Research octane number from 80 to 110.3. Sensitivities were 0.5 to 14.0.

Engines of two different combustion-chamber designs were used. An experimental V-8 engine of 287 cu in. displacement, Engine A, was operated at 8:1, 10:1, and 12:1 compression ratio. A production V-8 engine of 331 cu in. displacement, Engine B, was operated at compression ratios of 7.5:1 and 10:1. Both engines were installed on dynamometers and fully instrumented.

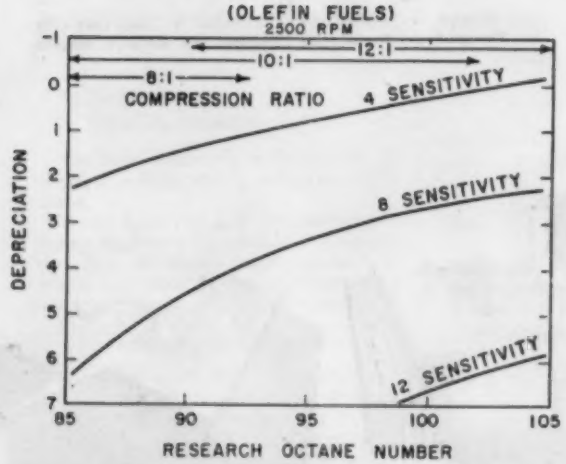


FIG. 1. Relationship of Research Octane Numbers to depreciation of olefinic fuels.

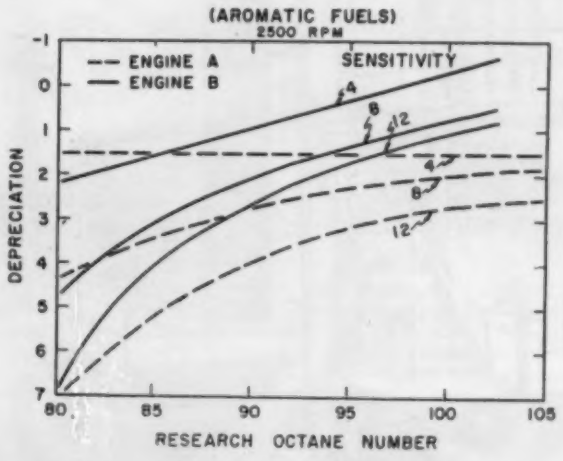
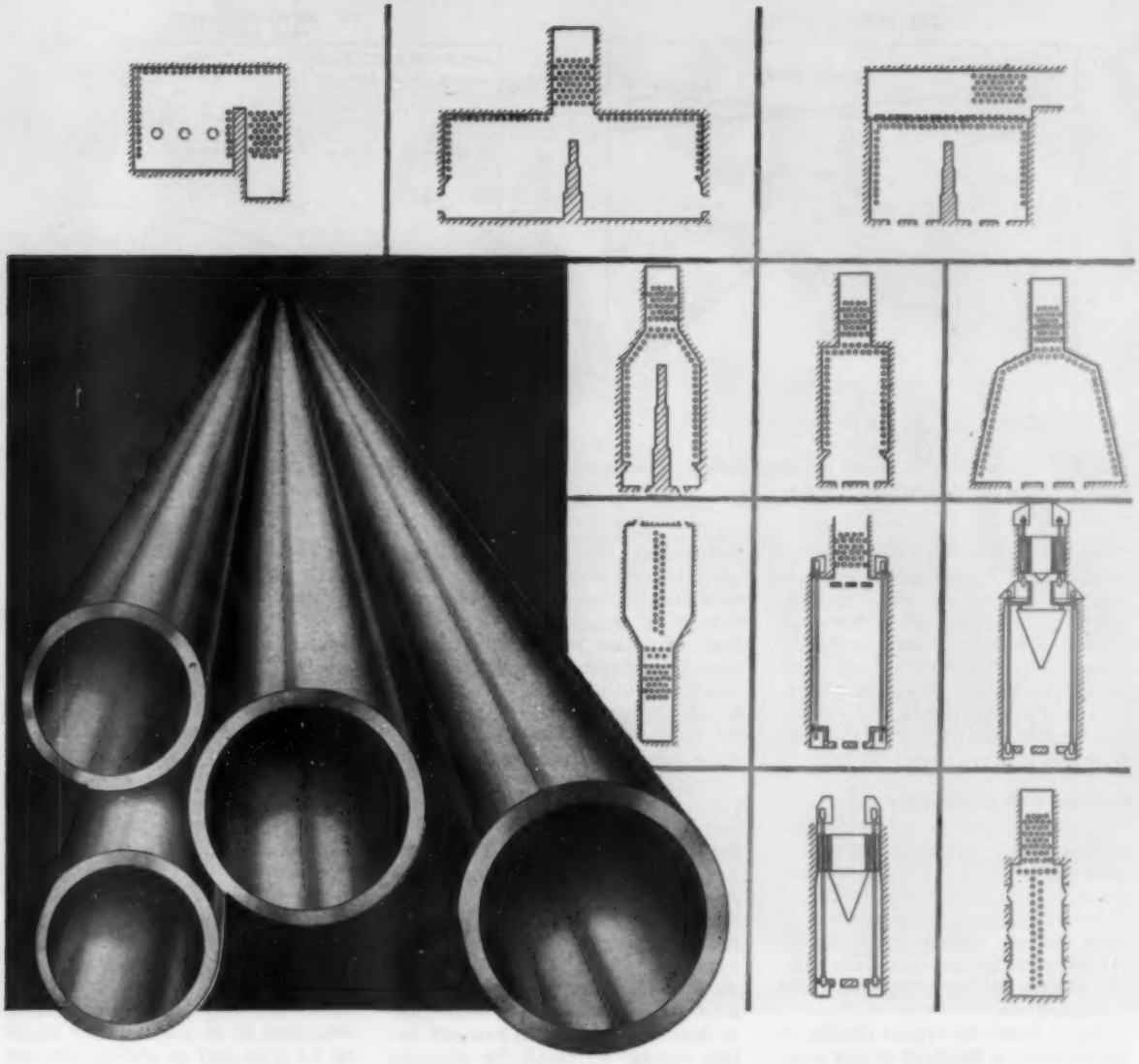


FIG. 2. Effect of combustion-chamber design on depreciation in Research Octane Numbers with aromatic fuels.



DESIGN ADDITIONAL SERVICE LIFE
INTO YOUR PROCESS HEATERS

...with B&W TUBING

Long service life of process heater tubing for the oil refining and petrochemical industries dictates selection of a B&W Croloy to insure maximum corrosion and oxidation resistance, and fully satisfactory handling of unusual temperature and pressure conditions which may arise. Mr. Tubes —your friendly link to B&W—has facts and figures to help you choose the best tube for the job. Get in touch with him to discuss your heater tube requirements, for both original equipment and maintenance. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-6062(P)

Seamless and welded tubular products, seamless welding fittings and flanges—in carbon, alloy and stainless steels

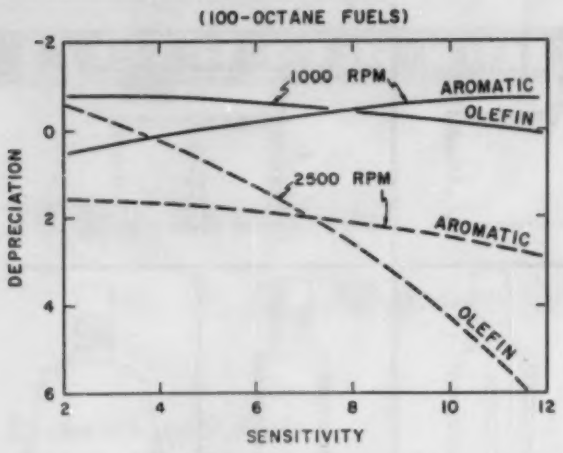


FIG. 3. Effect of engine speed on depreciation of various fuels of differing sensitivities.

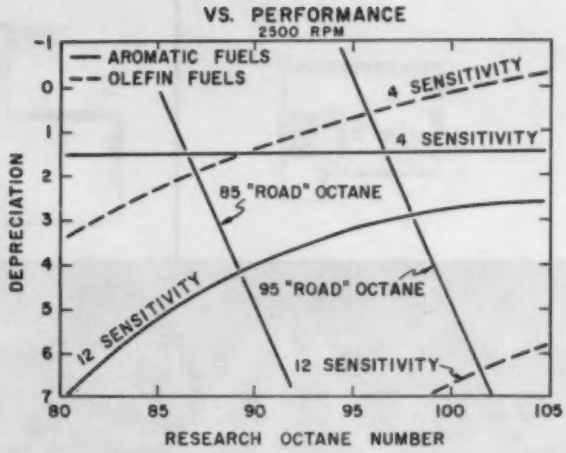


FIG. 4. Comparison of fuel qualities — sensitivity, road octane number — of aromatic and of olefinic fuels — with performance.

Fuels were rated by a technique developed by Ethyl Corporation to circumvent the spark-advance effects encountered in testing fuels on the road. Fuels were compared at the spark advance and fuel-air ratio for maximum power over the speed range of the engine; manifold vacuum at trace knock was used as the criterion of fuel performance at each speed.

Results and Discussion

For both engines at all test speeds and compression ratios, the relation of depreciation to Research octane number and sensitivity was then developed. Depreciation is the numerical difference between the Research octane number of a fuel and the octane number assigned to it by an engine at a specific condition.

Fig. 1 shows the typical relation of depreciation to Research octane number for olefinic fuels of various sensitivity. Data are from Engine A at 12:1 compression ratio and 2500 rpm. Depreciation decreased with increasing Research octane number and increased as sensitivity advanced. These ratings reaffirm the important effects of sensitivity on anti-knock performance. They also demonstrate that fuels of a given sensitivity level suffer less depreciation as octane number increases. Nevertheless, sensitivity is not necessarily less important as octane level rises. In fact, the effect of sensitivity on depreciation decreases only slightly in going from 90 to 105 octane number.

Varying compression ratio did not affect these trends. As further shown in Figure 1, there was no discontinuity in the octane areas in which compression ratio overlapped. For example, at 2500 rpm, an olefinic fuel of 91 octane number and 8 sensitivity was depreciated about 4.5 units at all compression ratios studied. The same behavior was observed with Engine B. Compression ratio thus has no specific effect on the severity of these two engines when fuels are rated by carrying throttle opening at maximum-power spark advance and fuel-air ratio. Clearly some factors affect the relationship between the laboratory and engine ratings of these fuels as octane number rises. Changes in resistance of the fuels to engine severity may be involved, as well as changes in the severity of the Research and Motor methods.

Combustion-chamber design did not affect the relation of depreciation to Research octane number and sensitivity for the olefinic fuels, as this relation was identical for both engines at all compression ratios. However, the engines rated aromatic blends differently, as shown in Figure 2. As Research octane number increased, the aromatic blends were rated higher in Engine B than in Engine A. The aromatic fuels perform better in the combustion chamber used by Engine B. Better utilization of fuels may well result from continued efforts by the engine designers to match combustion-chamber designs to the expected aromatic content of future fuels.

The depreciation of all fuels in both engines increased with engine speed. Figure 3 shows depreciation for 100-octane aromatic and olefinic fuels of varying sensitivity in Engine A at 1000 and 2500 rpm. The aromatic blends were affected far less than the olefinic blends. They offered a significant advantage over the olefinic blends in reduced depreciation at high sensitivity and high engine speed. This advantage was even greater in Engine B. Clear evidence is thus provided that Research and Motor octane numbers are no longer fully adequate to describe fuel anti-knock performance.

An over-all relation can be developed to characterize the anti-knock requirements of high-compression engines in terms of Research octane numbers, sensitivity, and hydrocarbon composition. Such a relation, based on Engine A at 2500 rpm, is shown in Figure 4. Superimposed are lines of constant "road" octane number assigned by Engine A. An engine requiring 95-octane primary reference fuel would be satisfied by an olefinic fuel of 4 sensitivity and 95.5 Research octane number; but, at 12 sensitivity, a fuel of 101.5 Research octane number would be required. This engine would also be satisfied by aromatic fuels of 96.5 Research with 4 sensitivity or 98 Research with 12 sensitivity. Thus, at the 12 sensitivity level, the road-octane advantage of an aromatic fuel would be 3.5 units over an olefinic fuel; but all would give the same power output as limited by anti-knock quality.

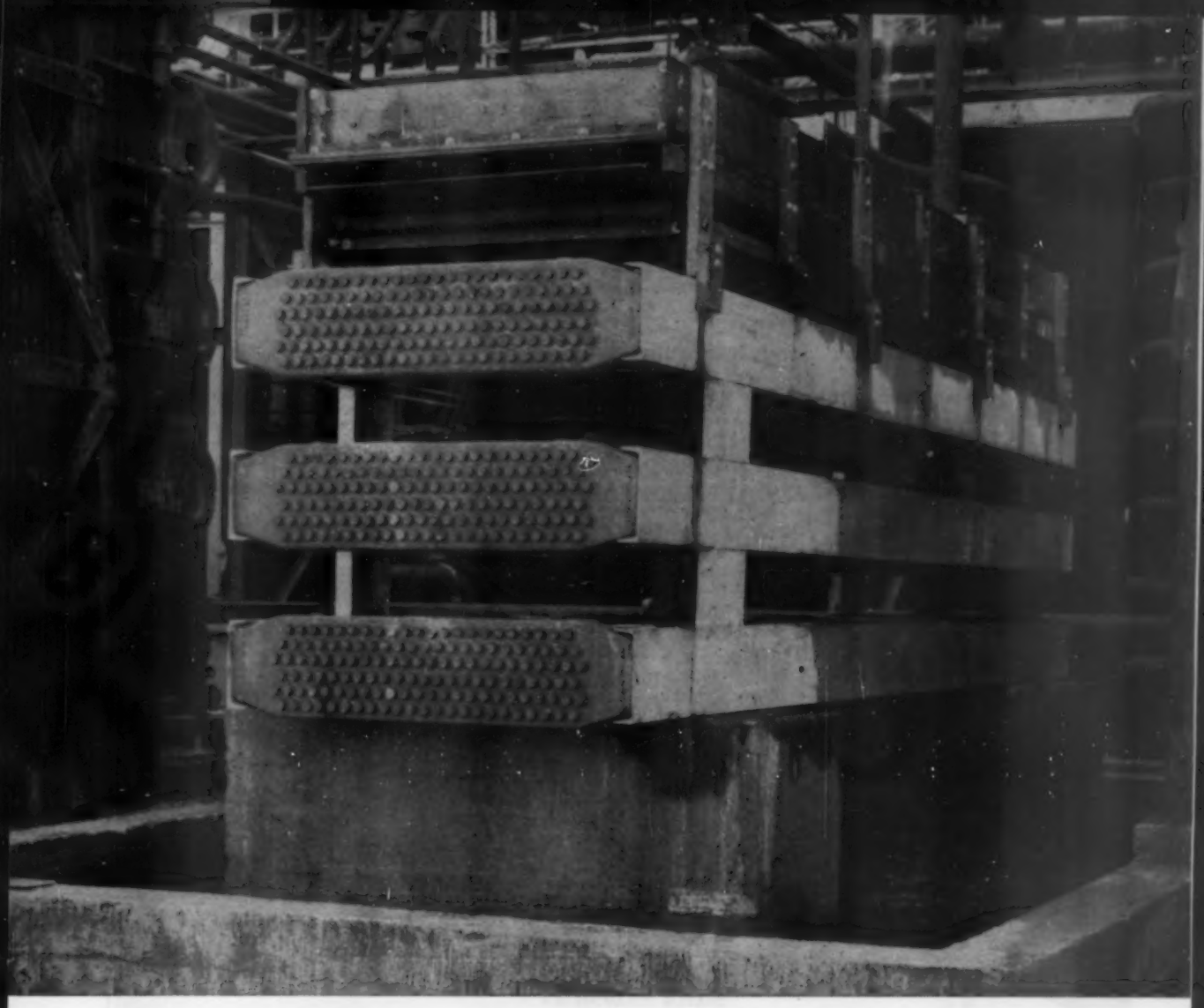
Conclusion

Road ratings on the highway will be required to confirm some of the implications of this study. In particular, the indicated "bonus" in performance from commercial blends of aromatic stocks needs to be further demonstrated. Preliminary road data confirm the laboratory effects of Research octane number, sensitivity, and composition on fuel ratings. Future experimental work will be extended to higher compression ratios if such work appears justified.

References

1. Roensch, M. M., Hughes, J. C., "Evaluation of Motor Fuels for High-Compression Engines." Presented at the SAE National West Coast Meeting, Los Angeles, California, August, 1950.
2. Boyd, A. P., Domke, C. J., White, P. C., "Future Gasoline for Future Engines." Presented at the SAE Golden Anniversary Fuels and Lubricants Meeting, Philadelphia, Pennsylvania, November, 1955.

★ ★ ★



less slime . . . more heat transfer with Stainless Steel tubes

Carbon steel tubes were previously used in this copper solution cooler, but they built up slime and scale rapidly. This reduced the heat transfer coefficient, and made it necessary to clean tubes frequently.

So the tubes were replaced with type 304 Stainless Steel. Cleaning has been practically eliminated. The tubes are expected to last indefinitely, and the increased heat transfer has reduced the output feed stock temperature by a good ten degrees.

Here is a Stainless Steel feature that is sometimes overlooked: the smooth, dense surface repels filth and contamination. In heat exchangers, this results in lower fuel costs and maintenance costs. As a bonus, you have the great corrosion resistance and strength that make Stainless Steel so popular in modern refineries. But be sure of service-tested quality; specify USS Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES
BARS • BILLETS
USS
PIPE • TUBES • WIRE
SPECIAL SECTIONS

6-1209

UNITED STATES STEEL

Rating differences no more than 0.2 octane number at low speeds; 0.7 octane number at high speeds

Road Ratings With a Chassis Dynamometer

P. E. Mizelle, J. C. Porter, and A. R. Rescorla
Cities Service Research & Development Company

IN 1937 the first road rating procedure to obtain octanes throughout the speed range was established. Since that time considerable progress has been made in road rating procedures and increased importance has been attached by the petroleum and automotive industries to road octane evaluation of fuels. Although gasoline blends of various stocks and at various lead levels are blended to a definite laboratory octane value, the final criterion as regards road anti-knock performance is vehicle road octane rating.

The use of a chassis dynamometer to conduct road ratings has the effect of bringing the road inside the laboratory and makes it possible for less personnel to obtain more ratings in a given day. In addition to expediting the number of ratings possible in a given day by a given crew a chassis dynamometer has other desirable features. By allowing ratings to be conducted indoors the problems associated with weather and traffic are largely eliminated. More nearly uniform conditions as regards atmospheric variables, vehicle load and wind velocity are obtained.

A cross section elevation view diagram of the Cities Service Research and Development Co. chassis dynamometer is shown in Fig. 1. The main items, such as rollers or traction drums, dynamometer, truck axles, fan and fan motors can be noted. The rear wheels of a vehicle drive the large traction drums shown in the left side of the drawing. Torque and horsepower are determined from the pull on the end of the torque beam located on the cradled truck axle housing. This pull, measured in pounds, is electrically transmitted to the instrument panel. An absorption dynamometer is located between the large rollers and the multivane fan to provide additional load, up to 300 hp, when required. Treated cooling water for the dynamometer is recirculated from a closed system. Water temperature is maintained below 180 F by automatic circulation to an outside radiator and fan. Two electrically operated clutches are located in the drive system. The clutch just to the right of the absorption dynamometer can be disengaged whenever it is desired to operate the multivane fan to provide air velocity different from vehicle speed. With this procedure all vehicle rear wheel power is absorbed at the dynamometer and the fan is driven by an electric motor and variable speed drive unit. The second clutch, located between the right side truck axle and fan, allows the fan to be

†Condensed by the authors from a paper presented at the SAE Golden Anniversary Fuels and Lubricants Meeting, Philadelphia, Pennsylvania, November 9-10, 1955.

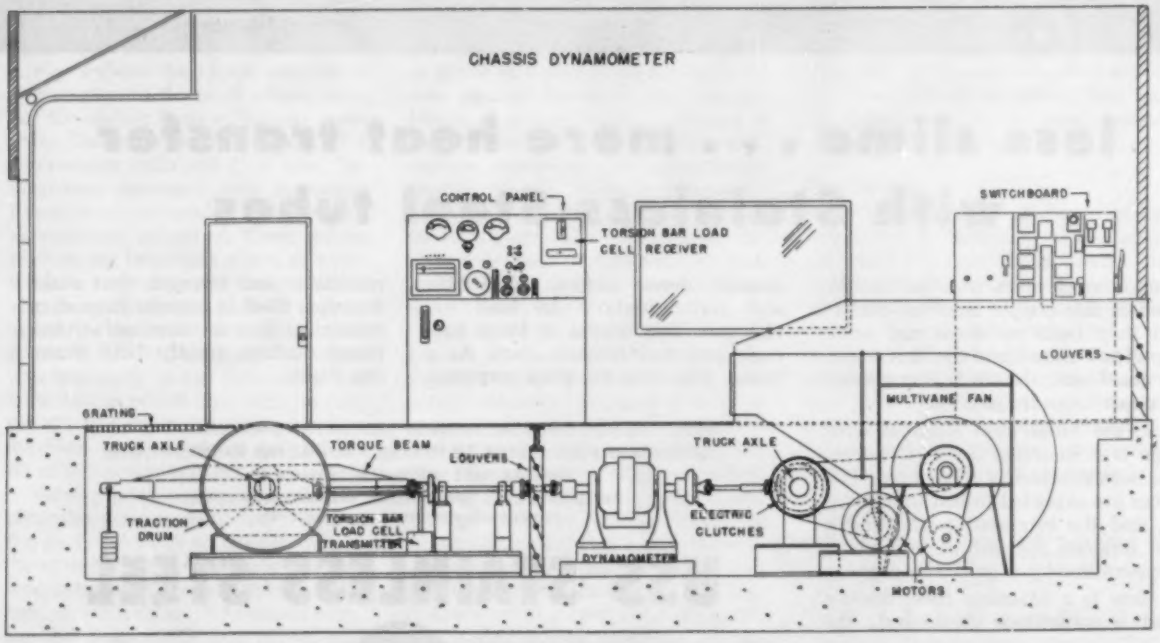


FIG. 1. Layout of chassis dynamometer assembly as employed in fuel rating tests.

For You

Catalyst "Know-How"

What makes one catalyst superior to another? Often it is the unseen ingredient, "know-how". Davison's long experience in successful catalyst production gives you this all-important element.

Davison, the first commercial producer of synthetic petroleum cracking catalysts, operates a modern plant for the sole purpose of producing specialty catalysts to aid industrial chemical progress. These catalysts can be custom made to your specifications. We guard your "know-how" as carefully as we do our own. They are made in many forms including granular, pelleted, powdered, spherical, extruded and include many supports and active agents.

Put Davison's "know-how" to work on your problem. No matter what your catalyst requirements are, it will pay you to discuss them with the Davison Field Service Engineer. A free booklet on Davison dependable catalysts is available on request.

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland

Sales Offices: Chicago, Illinois; Houston, Texas; New York, New York; Baltimore, Maryland

In Canada: Davison Chemical Company Ltd., Toronto

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels and Silicofluorides. Sole Producers of DAVCO® Granulated Fertilizer.

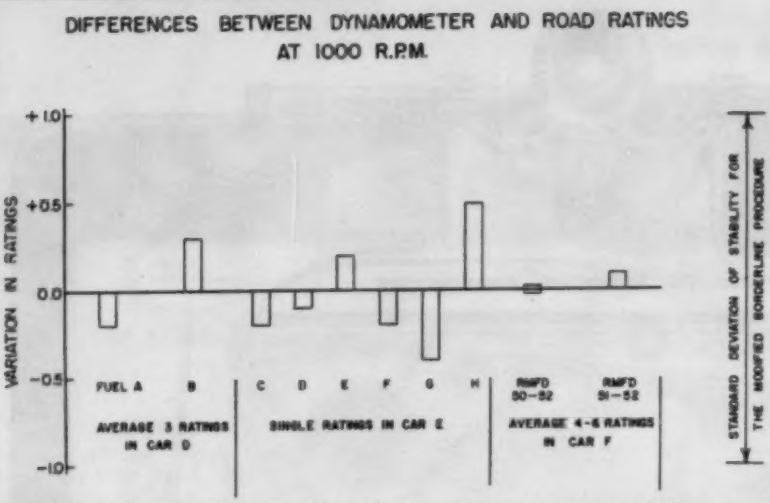


FIG. 2. Differences between dynamometer and road ratings at 1000 rpm.

operated at constant speed by a 15 hp electric motor. When both clutches are engaged the fan is driven by vehicle rear wheel drive through the system, or the fan and vehicle can both be driven by a 75 hp electric motor for vehicle friction tests.

The fan used to provide vehicle cooling air and also to act as part of the load is a multivane fan delivering 50,000 cfm at a discharge velocity of 80 mph. Two sets of louvers control air to the fan inlet. By adjustment of both sets the temperature can be maintained at any desired value equal to or above outside ambient. Vehicle road ratings throughout the year are, therefore, made under a nearly uniform set of conditions giving improved reproducibility.

The theoretical acceleration times far various vehicles on the dynamommeter were calculated and compared with theoretical acceleration times for level road. Actual acceleration tests were made on the road and dynamometer to verify the calculations. The theoretical and actual acceleration times from 10 to 60 mph on the road and dynamometer with a given vehicle did not vary more than 0.3 seconds.

A study was made of engine and vehicle temperatures on the road and dynamometer and indicated that temperatures at a given location in a given vehicle are approximately the same when operating on the road or dynamometer.

The chassis dynamometer has been in operation for approximately three years for the purpose of conducting vehicle octane ratings, octane requirement determinations and performance tests to evaluate fuels and lubricants. As discussed above vehicle operating conditions on the road could be duplicated on the dynamometer. Road octane ratings account for the majority of use and such ratings are comparable with those obtained on the open road.

The average variation between road and dynamometer ratings, based on the average of three ratings on the road and three on the dynamometer, in car D did not exceed 0.3 octanes throughout the speed range.

The average variation of single ratings of six fuels rated in car E was 0.3 octanes at low speed and 0.9 octanes at high speed.

Two fuels used in the 1952 Coordinating Research Council Road Rating Exchange Program were rated in car F on the road and dynamometer. The averages of four dynamometer ratings were compared with the averages of six road ratings throughout the speed range. Average variations of dynamometer minus road ratings did not exceed 0.2 octanes at low speed and 0.7 octanes at high speed.

A study of all ratings showed no definite plus or minus trend throughout the speed range when comparing ratings made on the dynamometer with those made on the level road. The differences between dynamometer and road ratings at 1000 rpm are shown by bar graphs in Fig. 2 and compared with the normally accepted stability of the Modified Borderline Road Rating Procedure. The magnitudes are less than the standard deviations of apparent stability (variation in series of ratings of same fuel at different times by same laboratory) and reproducibility normally accepted for the Modified Borderline Procedure. * * *

Process Monitor Mass Spectrometer Evaluated

A cooperative investigation to evaluate the Consolidated Type 21-260 Process Monitor Mass Spectrometer was recently completed by Consolidated Electrodynamics Corporation, and California Research Corporation engineers. The general conclusions reached were that the monitor was instrumentally sound, of value in pilot plant process development, and demonstrated capability of doing many refinery monitoring jobs.

Evaluation program included a laboratory application survey which covered a study of the instrument characteristics and the analyses of a number of gases and low-molecular-weight liquids. Laboratory results and conclusions were then verified on pilot plant installations.

The 21-260 process monitor is designed to continuously measure the amount of the various constituents in the process stream. Known as a "cycloidal focusing" mass spectrometer, it provides a much higher resolving power and extended range.

To uncover problems that would be encountered in pilot plant and refinery work, the instrument was hooked directly to a pilot plant cracking unit, polymer unit and other units.

In the pilot plant cracking unit, the off-gas originating from the debutanizer column and the recycle gas were examined. In the case of the off-gas, the unit determined methane, ethane, propane, n-butane, isobutane, and hydrogen sulfide contents. Recycle gas, which was principally hydrogen, was monitored for methane, ethane, hydrogen sulfide, and propane. The results obtained compared favorably to those obtained on larger analytical instruments.

In a polymer unit, propane-propene mixtures containing small amounts of C_4 hydrocarbons were fed into the polymerization chamber and the reaction product ultimately sent through a depropanizer column. It was possible to follow in the feed the concentration of the propane and the propene as major constituents and also to determine the minor percentages of butanes and butenes.

In a test on a small pilot plant platforming unit benzene, toluene, and C_8 naphthenes were monitored.

It was also found that both the feed and product could be analyzed for benzene, toluene, methylcyclopentane, cyclohexane, and total C_7 naphthenes.

Results obtained in these tests demonstrated the potential application of the instrument to pilot plant analysis and development of optimum operating conditions. Through the continuous monitoring program it is possible to rapidly evaluate variables such as pressure, temperature, flow rate, and feed composition, and their effect on product.

Cut evaporation losses with DULUX® Tank White Enamel

Today, major oil companies have found a way to give their huge oil-storage investments top protection against evaporation—at top economy—by painting tanks with DULUX Tank White Enamel.

REFLECTS THE SUN'S HEAT. Petroleum experts agree that painting a tank white results in heat reflectance that sharply reduces costly evaporation losses. Many users report evaporation cut close to 85% on tanks painted with DULUX Tank White. Titanium dioxide, the whitest pigment ever employed in paint, is used for maximum reflectance. And the controlled chalking of the DULUX finish prolongs this exceptional brightness. Tanks actually clean themselves.

APPLICATION SAVINGS. You save the time and expense of a two-scaffold setup when you paint with DULUX Tank White. The second coat of paint can be sprayed on immediately at right angles to the first—a single operation. DULUX applies fast, dries fast.

MAINTENANCE SAVINGS. Painting cycles are extended for years with DULUX Tank White. The rugged DULUX resin base ensures exceptional resistance to corrosion, industrial gases, and rough weather.

Learn how you can cut evaporation losses and save on maintenance and application—write today for your free "Beat the Heat" booklet.

DU PONT
REG. U.S. PAT. OFF.

Petroleum Industry Finishes

Du Pont has the right finish for every petroleum-industry need

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Finishes Division, Dept. PE-96
Wilmington, 98, Delaware

Please send, free of charge, your illustrated booklet **BEAT THE HEAT.**

*Name*_____

*Address*_____

*City*_____ *State*_____

petrochemicals

Look for New Instruments

R. G. Marvin, W. L. Stuart, G. W. Lunsford, and E. E. Ludwig. *Texas Division, Dow Chemical Company*

THE primary purpose of this paper is to emphasize the active interest of petrochemical plants in new instruments and in their development for process applications.

Automatic Computer

Automatic computers in industry are relatively new and probably confined to the last 8 to 10 years as far as widespread industrial applications are concerned. The use of this equipment by government agencies or government-sponsored agencies preceded this period and still carries on. Industry as a whole has awakened to the possibility of automatic computation and data processing and has begun to participate strongly in the application of this equipment.

Automatic computer applications fall into the classifications of (1) office procedures, which includes filing, sorting, processing of records, data, etc.; and (2) scientific, which includes computations and system analysis by simulation. Computer equipment is divided into digital and analog types and each has its respective area of application with only a small degree of overlap.

Here are a few selected computational problems that have been solved economically on automatic computing equipment:

Analog	Digital
1. System Simulation	1. Distillation
2. Differential Equations	2. Horizontal Tank Gauge Tables
3. Arithmetic Operations	3. Traffic — Economic Shipping Points
4. Heat Transfer	4. Refinery Economical Balances
5. Acoustics	5. Fluid Flow
6. Fluid Flow	6. Process Reaction Kinetics
	7. Differential Equations
	8. Payroll
	9. Inventory Control

Relative Flow Measurement at High Pressure

The measurement of the flow of gases at high pressure has been a rather difficult service for instruments. Some work has been done and is continuing to be done to improve the accuracy of absolute measurement of gas flow in the region of 3000 to 50,000 psi.

The petrochemical company undertook to solve a problem of relative flow measurement in this pressure range.

In this installation one flow is compared with another flow which is parallel and which fluctuates in a somewhat similar manner. Control can be established from any selected point and should give relative readings. The pressure differential is picked up by a special high pressure differential pressure transmitter and the readings are recorded in the control room. Control valve adjustment to keep the systems balanced is made by pneumatic remote hand valve operation. The paper gives details of the installation. A schematic arrangement is shown in Fig. 1.

Ratio Flow Control of Two Gas Streams in a Process

There are some petrochemical processes that use gas phase reaction. To make the operation efficient and successful, close control of the raw material is necessary. Failure to meet this requirement could result in loss of production, and waste of power and other services in handling the process constituents.

Control for gas phase reaction can be solved by use of standard flow instruments properly integrated to give the required material quantities. The schematic arrangement is shown in the attached Fig. 2.

Use of Strain Cell for Pressure Control

The problem of controlling piping system pressures above those of normal operations with fast speed of response was solved by the use of a strain cell. The process encountered was such that normal lags in transmission from the primary element and final control loop could not be tolerated. To fulfill this requirement, a resistance strain pressure cell was chosen as the primary device with an electronic type receiving instrument calibrated with a suppressed reading. The receiving instrument's pneumatic output signal is converted to an electrical signal for transmission and is reverted to a pneumatic signal near the pneumatically operated control valve. The converting from a pneumatic signal to an electrical valve for transmission was handled by an electronic pressure transmitter and servo-electrical pneumatic transducer. Fig. 3 shows the schematic arrangement.

Control of An Absorption Refrigeration System

Absorption systems utilizing ammonia have been in industrial refrigeration service for many years. In general, they are an economical source of moderately low level refrigeration when the tonnage capacity exceeds 200-300 tons.

Experience with the control of these systems indicates that application of good instrumentation principles will give a satisfactory system. The paper describes the instrumentation used by the petrochemical plant compared to other recommended schemes.

Flow Measurement of High Pressure Gas Streams

(Impeller Type Flow Sensing Cell)

The problem of measuring and recording process gas flows at pressures above those normally encountered was the subject of recent study. Various methods of flow measurement were investigated with the impeller type flow sensing cell appearing to have the pri-

This Ell Bolt is the Key to leak control

The patented Ell Bolt construction employed on Vogt floating head heat exchangers is the answer to re-assembly without distortion or leak development.

Cover may be removed by simply loosening the Ell Bolt nuts and disengaging the Ell Bolt heads from the "lock notches." No misplacing of Ell Bolts can result — and tightening is easy and positive — absolutely leak proof. Send for Bulletin HE-6. Address Dept. 24-XPE.

Vogt

HENRY VOGT MACHINE CO., P. O. BOX 1918, LOUISVILLE 1, KY.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati, San Francisco

OTHER VOGT PRODUCTS
Drop Forged Steel Valves, Fittings and Flanges in a complete range of sizes • Petroleum Refinery and Chemical Plant Equipment • Steam Generators • Heat Exchangers • Ice Making and Refrigerating Equipment.

HEAT TRANSFER EQUIPMENT

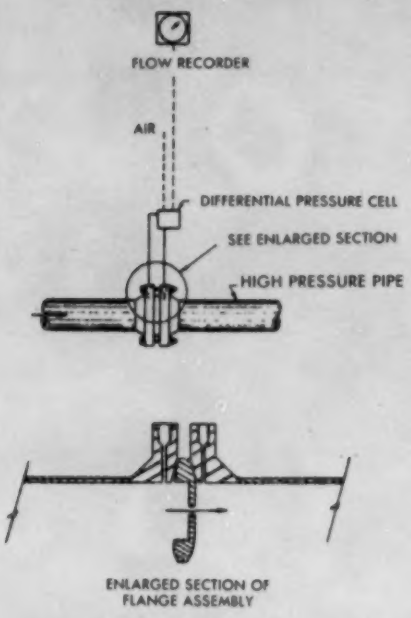


FIG. 1. Schematic arrangement of flow-measurement-at-high-pressure system.

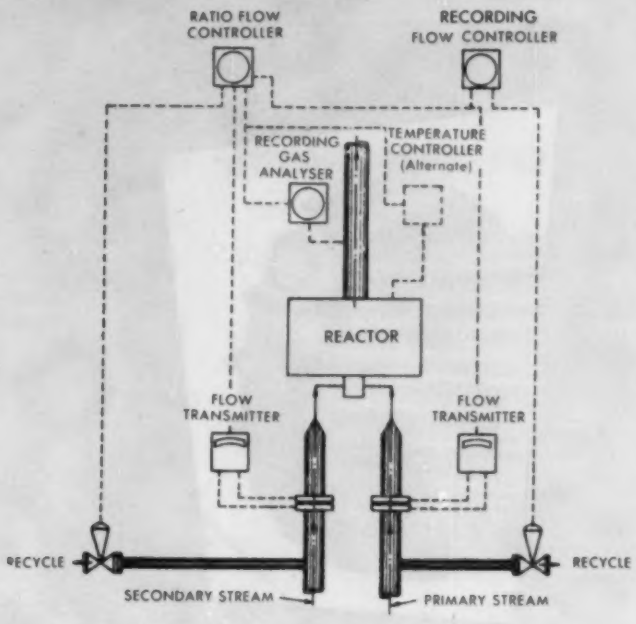


FIG. 2. System for ratio flow control of two gas streams.

mary device characteristics required. It was desired to measure and record two flows on a single recorder chart with a choice of selection of either one of the flows as a pneumatic control device. Since the controller was to be located in an electrically hazardous area, the use of an electronic instrument was not permissible.

Flow cells were installed directly in the high pressure piping with the sensing coil mounted outside the pipe line. There is no physical connection between these two elements, which is a definite safety advantage. The output voltage from each cell was fed into a converter, then through electrical conductors into electro-pneumatic units located near the main control panel.

By using this scheme, the pneumatic pressure signals were fed directly into a conventional two-pen recording receiving controller with control point being manually selected by the operator.

This application is shown schematically in Fig. 4.

Although it is recognized that the examples given may be known to some engineers active in instrument work, we believe that they do serve to emphasize the interest of petrochemical companies in this subject. With continued close cooperation between manufacturer and user, many tough problems of today will undoubtedly be solved tomorrow. ★ ★ ★

FIG. 3. Hookup for controlling pressure by use of a "strain-cell."

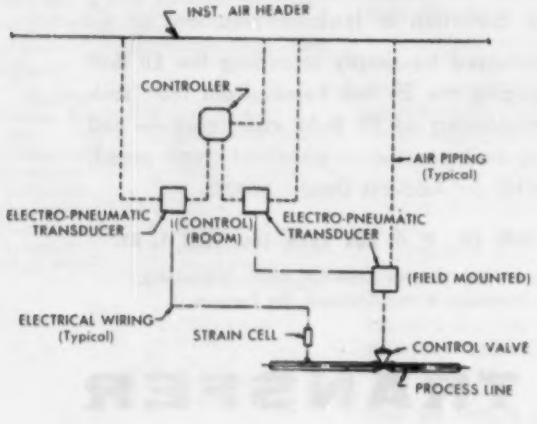
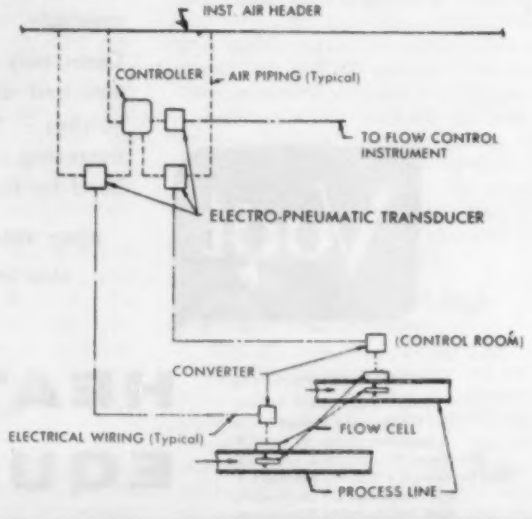


FIG. 4. Method of installation of flow sensing cells in high pressure streams.



New tower goes to English plant. Light, efficient, all-Monel nickel-copper alloy "Turbogrid" design reduces both construction and operating costs of this mesityl oxide unit designed by Shell Development Company.

New, all-Monel mesityl oxide tower points way to lower fractionating costs

Shell—*designed Turbogrid unit is expected to operate at high capacity with low maintenance.*

Things are popping in bubble tower design.

Take this all-Monel* nickel-copper alloy distillation tower. When all facts are in, it may prove the forerunner of all-Monel alloy construction for units where only carbon steel is used today. With this type of alloy construction, longer tower and tray life, lower maintenance, and greater operational versatility can be expected.

The column (shown here on its way to the Stanlow Refinery of Shell Refining and Marketing Company in Cheshire, England) separates mesityl oxide from hot, acid-treated diacetone alcohol. It is 55 feet high, fitted with 40 Shell Turbogrid trays . . . stamped from Monel alloy plate.

Slotted grids provide highly efficient vapor-liquid interchange. There are no dead zones. Pressure drop per tray is low and very high throughput is obtained. Fouling is slow. Cleaning easy.

The Monel alloy trays are amazingly light: because of simple construction (which results in low liquid hold-up) . . . and because the strength and corrosion resistance of the alloy permit thin gauges.

The result? Much lighter, less costly structure, and lower fabrication and construction costs.

In this instance the anticipated cost differentials justified Monel nickel-copper alloy for tower shell as well as trays. It is expected that actual operation will reveal additional savings. This would extend the use of this alloy to many refining and petrochemical fractionators where corrosion has been an accepted trouble in the past.

If you face this situation and would like to discuss the possibilities with one of Inco's Development and Research engineers, contact . . .

*Registered Trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

Monel . . . *for minimum maintenance*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

P 815.51

Road Octane Ratings Obtained In a Single-Cylinder Engine

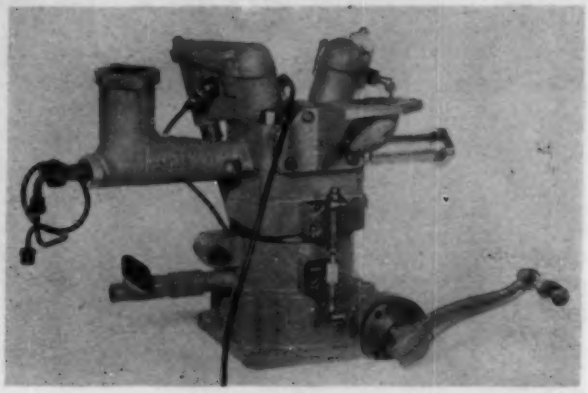


FIG. 1. "Single Cylinder" head assembly for testing engine.

E. M. Barber, H. I. Wilson, and T. H. Randall

Research and Technical Department, The Texas Company

IT has been known for many years that motor gasoline octane number ratings, as measured by the ASTM Research and Motor methods, may differ from those obtained in automobiles operated under normal driving conditions. Some fuels which exhibit adequate antiknock quality as measured by the laboratory engine might knock in customers' cars while other fuels that are rated lower in antiknock quality by the laboratory engines might give knock-free performance in customer use. The car-to-car differences in fuel road octane ratings obtained in a group of typical cars is usually less than the differences which exist between road ratings and those obtained in the above laboratory methods. These latter differences may be as great as 10 octane numbers.

This situation is not surprising, since:

1. Octane ratings are determined relative to reference fuels of specified composition.
2. Fuel antiknock performance depends on fuel composition and on engine design features and operating conditions.

Improved ability to describe road performance in terms of laboratory ratings has always been of considerable economic importance. It becomes even more so as automotive engines develop appetites for higher and higher fuel octane numbers. The automotive and petroleum industries have worked on the problem for years, but over-all progress has been quite slow.

In their approach to this problem, the authors started with the theory that the occurrence of knock depends on whether reactions in the end gas, i.e., the last part of the charge to burn, reach the point of spontaneous ignition before the end gas is consumed by the normal flame front. The variables that affect knock, such as engine operating conditions and combustion chamber design factors, were then considered in terms of their effects on the more fundamental quantities of end gas pressure and temperature, and residence time.

First, performance and combustion characteristics of the standard knock test method engines and of a substantial group of automotive engines were reviewed. This showed that the knock test engines rate fuels at quite different conditions than do automotive engines.

In a systematic series of programs, a basic ASTM knock test engine was operated at conditions selected to produce typical automotive values of com-

[1]Supervisor, Special Engine Research Department.
[2]Project Leader, Fuels Group, Engineering Research Department.
[3]Mechanical Engineer, Engineering Research Department.
A condensation, by the authors, of their paper presented to the SAE Summer Meeting, June 6, 1956.

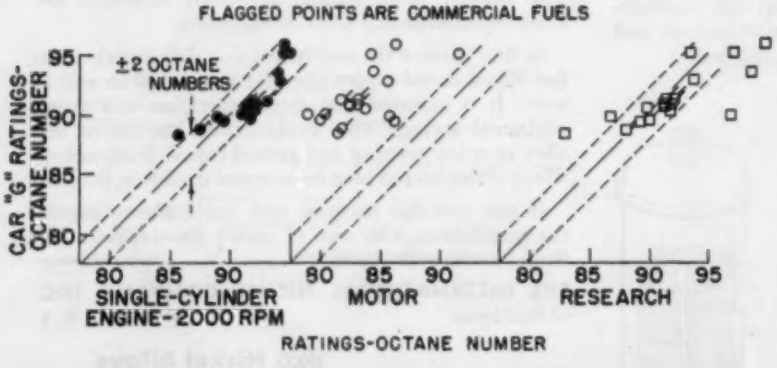


FIG. 2. Curves showing degree of agreement between octane ratings determined on the road, in one car engine, and ratings found in the single cylinder test engine.

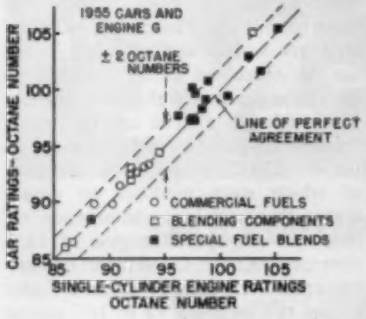


FIG. 3. Comparison of the averages of ratings of 9 1955 model cars, modified to give higher than standard compression ratios, with the closely agreeing single cylinder test engine ratings.

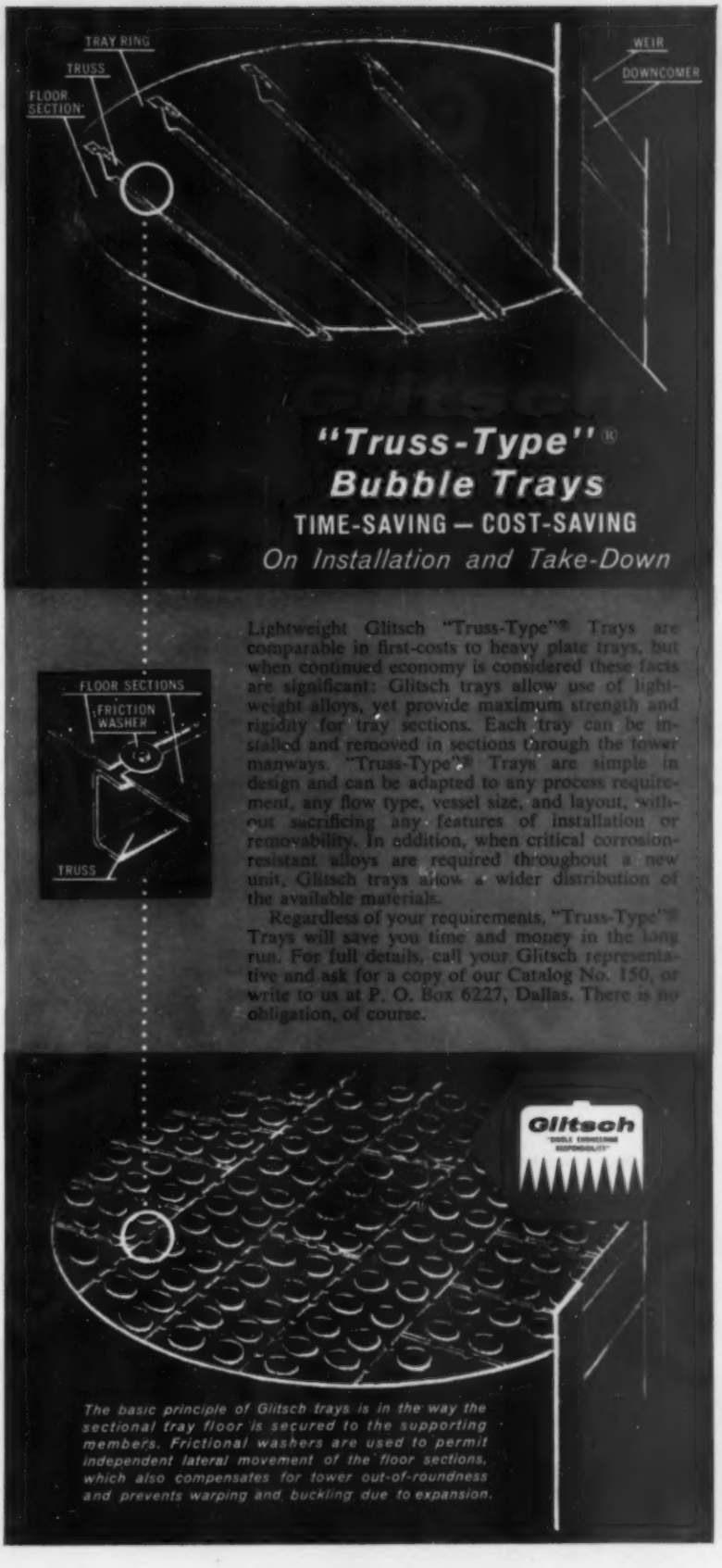
pression density, compression temperature, and mixture strength. However, the desired improvement in agreement of octane ratings was not obtained. This was attributed to longer burning times in the ASTM knock test engine.

Investigations of combustion chamber design, as a means of influencing the combustion time, led to the use of a specially designed, domed cylinder head and cylinder assembly, hereafter referred to as the "single-cylinder" assembly. This latter assembly has a more nearly central spark plug location than does the ASTM engine. This spark plug location, together with a mild "squish" turbulence, provides a reasonably short burning time. The photograph shows this assembly in final form, adapted to provide continuous compression ratio variation similar to that of the ASTM engine.

Comparative Borderline Road Octane-type of reference fuel frameworks and fuel octane ratings on a substantial number of fuels showed good comparison in knock-limited performance between the single-cylinder engine and the cars, considered both individually and as groups. Similar trends and good numerical agreement were obtained.

An extended series of programs using a direct bracketing type of rating procedure were then conducted. The fuels used encompassed a wide range of commercial products, special blends of refinery stocks, and mixtures of individual hydrocarbons; road octane numbers ranged from 68 to 105. Car road octane ratings were obtained on a variety of 1947-52 and 1955 cars; compression ratios varied from 6.5 to 12, with the higher ones being obtained through use of special pistons, cylinder heads, and engines.

Typical results of this work are shown in the figures. The first figure shows good direct numerical agreement


TRAY RING
TRUSS
FLOOR SECTION
WEIR
DOWNCOMER
"Truss-Type"®
Bubble Trays
TIME-SAVING — COST-SAVING
On Installation and Take-Down
FLOOR SECTIONS
FRICTION WASHER
TRUSS
Lightweight Glitsch "Truss-Type"® Trays are comparable in first-costs to heavy plate trays, but when continued economy is considered these facts are significant: Glitsch trays allow use of lightweight alloys, yet provide maximum strength and rigidity for tray sections. Each tray can be installed and removed in sections through the tower manways. "Truss-Type"® Trays are simple in design and can be adapted to any process requirement, any flow type, vessel size, and layout, without sacrificing any features of installation or removability. In addition, when critical corrosion-resistant alloys are required throughout a new unit, Glitsch trays allow a wider distribution of the available materials.
Regardless of your requirements, "Truss-Type"® Trays will save you time and money in the long run. For full details, call your Glitsch representative and ask for a copy of our Catalog No. 150, or write to us at P. O. Box 6227, Dallas. There is no obligation, of course.
Glitsch
The basic principle of Glitsch trays is in the way the sectional tray floor is secured to the supporting members. Frictional washers are used to permit independent lateral movement of the floor sections, which also compensates for tower out-of-roundness and prevents warping and buckling due to expansion.

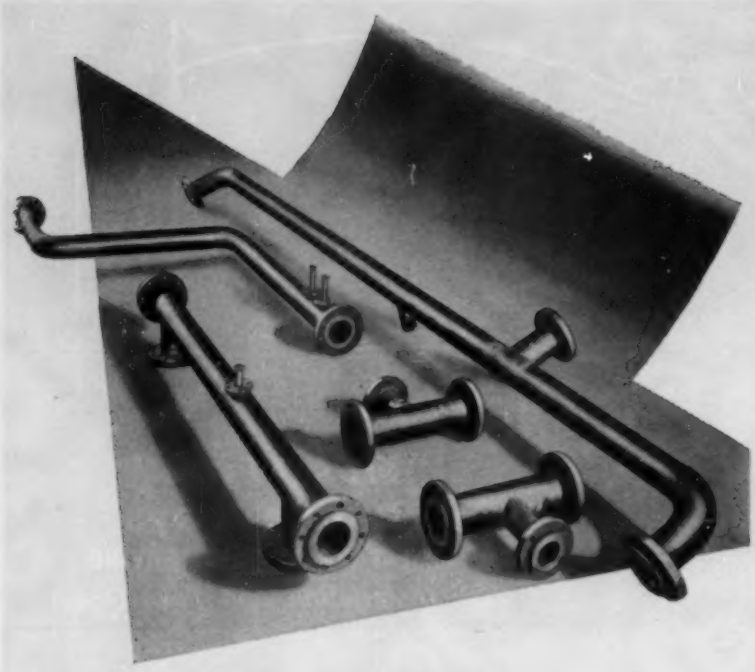
between single-cylinder ratings and those for one car. The standard method tests are widely scattered and could not be combined in any fashion to match the agreement shown by the single-cylinder data. The car ratings of the second figure represent the averages for 8 — 1955 model cars, most of of which were modified to obtain higher than standard compression ratios, and one special engine of 12:1 compression ratio. Good direct numerical agreement for the single-cylinder engine ratings from 85 to 105 octane number is evident.

The authors feel that one need not expect to find highly exact correlation between laboratory single-cylinder engine ratings and road octane ratings obtained from groups of automobiles of varying make and model. A continuing series of programs with the technique described shows:

1. The mean line of the comparisons is a line of numerical agreement; this is an improvement over the ASTM Research and Motor methods.

2. Maximum differences between single-cylinder engine ratings and road octane ratings are three octane units which is also an improvement over the ASTM Research and Motor method ratings.

This improvement in comparative ratings is attributed primarily to selection of a suitable combustion environment. Combustion conditions in the single-cylinder engine approach those of typical automotive engines more closely than do those in the ASTM Research and Motor methods. It is implicit in this approach that changes in the single-cylinder technique may be required to maintain the combustion environment comparability. Evidently, however, the requirement for change need not be drastic or frequent, since it appears that fine details of automotive engine design and operation do not require duplication. The authors feel that their experiences may contribute to the development and improvement of laboratory methods for obtaining fuel octane ratings that correlate well with antiknock performance in typical consumer service. * * *



Tough piping problems made easier with AMPCO* PIPE

. . . the pipe that resists corrosion and velocity damage, withstands mechanical abuse

Put Ampco Pipe on your tough, liquid-handling jobs, and, mister, you've got something. First of all you've got pipe that's easier and less costly to install. It stands up under wrenches and hammers without thread distortion and subsequent leakage. It is readily welded with shielded arc procedures. "On-the-job" changes and maintenance may be done by the average weldor.

Pipe made from this unique aluminum-bronze alloy is hard, yet it's unusually tough — gives you Brinell hardnesses of 150 and tensiles up to 70,000 psi. It has high strength-to-weight ratios.

But here's the best part of the story. It is highly resistant to many acids and caustics. It has high velocity tolerance—permits flow rates up to 18-20 fps. It withstands the action of abrasive solids in suspension and resists cavitation-pitting. It combines the advantages of many different pipe materials without their drawbacks.

What's more, you can get Ampco Pipe in all standard sizes, many from stock. Fittings are also available to 3600 psi and flanges to 5000 psi. Write us now for full information.

AMPCO

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept. PE-9, Milwaukee 46, Wisconsin

West Coast Plant
Burbank, California

PE-19

*Reg. U. S. Pat. Off.

Master GLASSES

HIGH PRESSURE GASKETS

All sizes to fit your gages
ERNST WATER COLUMN & GAGE CO.
Send for Catalog LIVINGSTON, N. J.

"M-S ··· M-H"

(MAXIMUM SERVICE - MINIMUM HEADACHE)

from WESTERN HEAT EXCHANGERS

And Here's Why

The accelerated pace of today's business problems, whether they be in engineering, operations, sales or management, makes it more important than ever that the supplier of your process equipment be attuned to *your* specific needs.

Many Operating and Engineering executives in the petro-chemical field, from both large and small companies, have found Western Supply Company to be *their* kind of supplier in design, fabrication and service of Heat Exchangers.

And, we believe, for good reason . . .

WESTERN'S *Specialists*

. . . are highly trained, flexible, young and experienced, having a full appreciation and acceptance of the heat transfer problem . . . using the latest and best data available.

WESTERN'S *Accurate Ratings*

. . . are a result of the technical skill of Western's engineers, the latest data and their knowledge of field-proven installations — assuring that each exchanger is sized to give the most economical unit for the job.

WESTERN'S *Modest Size*

. . . makes Western easy to do business with . . . flexible in thought, ingenious in design, fast-moving in emergencies.

WESTERN'S *Techniques and Tools*

. . . include all of the latest machines and equipment necessary for producing quality equipment, with skilled craftsmen in direct supervision over each step of fabrication.

WESTERN'S *Personal Attention*

. . . to each detail of our customer's specifications and needs can be traced from the initial contact to the finished product, resulting in a close customer relationship thru the years.

Western Heat Exchangers merit your consideration on your existing or future heat transfer requirements. We'll appreciate your inquiry.

WESTERN
HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
P. O. BOX 1888 • TULSA, OKLAHOMA

HUDSON-RUSH COMPANY — 753 Gladstone Blvd., Shreveport, La.
130 Casa Linda Plaza, Dallas, 18, Tex.
P. O. Box 3151, Amarillo, Tex.

PROCESS INSTRUMENTS & EQUIPMENT CO. — North Bldg., Charleston, W. Va.

H. W. SEVERANCE — 2416 Frankfort Ave., Louisville, Ky.

From Tower to Tank Car...

rely on

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Rely on Oakite for Cleaning Processing Towers:

Modern Oakite detergent-circulation methods eliminate needless expense for special work crews. Oakite "in-place" cleaning materials minimize dismantling . . . considerably reduce total offstream time.

Rely on Oakite for Cleaning Heat Exchangers:

Oakite offers specialized alkaline and acidic type compounds for removing numerous types of oil, carbon, lime scale and rust. Cleaning is done in place by safe, thorough chemical circulation methods.

Rely on Oakite for Paint Stripping:

Oakite provides a complete selection of alkaline and solvent paint strippers. The specialized Oakite Hot Flow-On method permits storage tanks and towers to be stripped in a fraction of the time required by manual methods.

Rely on Oakite for Salvage Reclamation:

Scientifically developed Oakite derusting and degreasing techniques help make salvage work profitable . . . help speed up inspection and repair. Oakite's mechanized cleaning techniques eliminate arduous and time-consuming manual cleaning . . . are simple, effective, and economical.

FREE: A valuable 48-page petroleum manual gives complete details about these and hundreds of other maintenance cleaning jobs in all petroleum divisions. Send for your FREE copy today—without obligation. Write Oakite Products, Inc., 44C Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Moving to a New Address?

If you are moving or expect possibly to move any time soon, save the coupon below for your convenient change of address. It will prevent your copy of The Petroleum Engineer from being lost or misdirected.

TO: The Petroleum Engineer
P. O. Box 1589 • Dallas

CHANGE MY ADDRESS, beginning with the

_____ issue

FROM: _____

_____

_____

TO: _____

_____

_____

IN-BUILT SIMPLICITY...

GUARANTEES

LONG, TROUBLE-FREE SERVICE

Here's the simplest and most efficient pump valve made for reciprocating pumps. The ROYAL CROWN PUMP VALVE has only three separate parts, yet its performance is revolutionary! Valve is guided by a frictionless ball stem which allows it to oscillate and turn with the fluid stream. Swings completely free with each stroke of the pump . . . seating each time in a new position. Resistance to fluid is reduced to a minimum which means greater pump volume at less pump speed. Adaptable to all reciprocating pumps . . . handles all types of liquids.

Royal Crown PUMP VALVES

(A) Round valve surface is streamlined. No obstructions to restrict the flow. (B) Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing . . . a lapping action, a continuing perfect seat. (C) Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

BLH
MADSEN WORKS
CONSTRUCTION EQUIPMENT DIVISION
Baldwin-Lima-Hamilton Corporation

WRITE FOR DESCRIPTIVE LITERATURE

14130 EAST ROSECRANS AVE., P. O. BOX 38, LA MIRADA, CALIFORNIA

REFINERY PLANTS SCHEDULED FOR COMPLETION

Lube solvent dewaxing unit. Standard Oil Company (Indiana) is building a new solvent extraction unit for dewaxing lubricating oils to make low pour point products, at its Whiting, Indiana, refinery; capacity will be about 800 bbl per stream day. Urea is the solvent, having the property of forming adducts or loose combinations with paraffin waxes, that is, straight-chain hydrocarbons, removing them from the fraction, and later the combination is broken to free both solvent and hydrocarbon waxes.

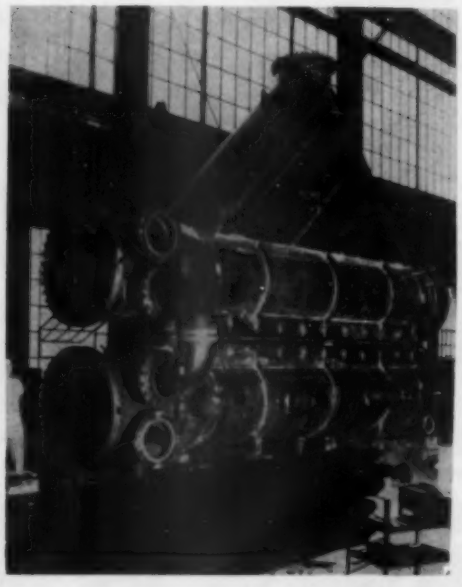
Reformer and extraction unit for Canada. A 4400 B/D Platformer unit and an affiliated Udex extraction unit will be built by Canadian Oil Companies, Ltd., at Sarnia refinery. The Udex plant will have 3650 B/D capacity and will process the entire output of the Platformer, the second one at this plant.

Venezuelan refinery for 1957. A refinery of 3000 bbl per day capacity will be built for the Venezuelan government's Ministry of Mines and Hydrocarbons near Moron, on the Caribbean coast, and will be operated in conjunction with the petrochemical industry also planned for that country. The American firm of Blaw-Knox will be general contractor for these jobs. The petrochemical industry will utilize some of the 600 billion cu ft of casinghead gas now flared in Venezuela annually.

Another Texas City reformer. A second Ultraformer is being built by American Oil Company at Texas City, Texas, of 21,000 B/D capacity, to be completed before the end of 1957. Bids are being called for and work is expected to start within two months or so. Naphtha desulfurization capacity will be built for this unit, also.

Breaking ground for new Houdry Process lab. Dr. Alex G. Oblad, vice president and director of research and development (center, hands in pockets), and Theodore A. Burtis, associate manager of research and development (holding chrome-plated spade), officiate at ground-breaking for new 10,000-sq ft building being added to facilities of Houdry Process Corporation Research and Development Laboratories at Linwood, Pennsylvania, near Marcus Hook. Research and development section chiefs and 20-year employees took part in ceremony.

40-Ton G-R condenser, 80 ft up, part of Gulf Oil's new 100,000 B/D unit.



New fuels-lubes research laboratory. An Army Ordinance research laboratory is to be built adjacent to the Southwest Research Institute at San Antonio, Texas, to cost about $750,000. Ground was broken for the two buildings in July, and these buildings will include nearly 13,000 sq ft of floor space, plus a basement under part of the main research unit. Ordinance Department of the Army will conduct long-range research into the fuel and lubricant needs of weapons of the future, utilizing the research staff and facilities of the institute as well as military personnel.

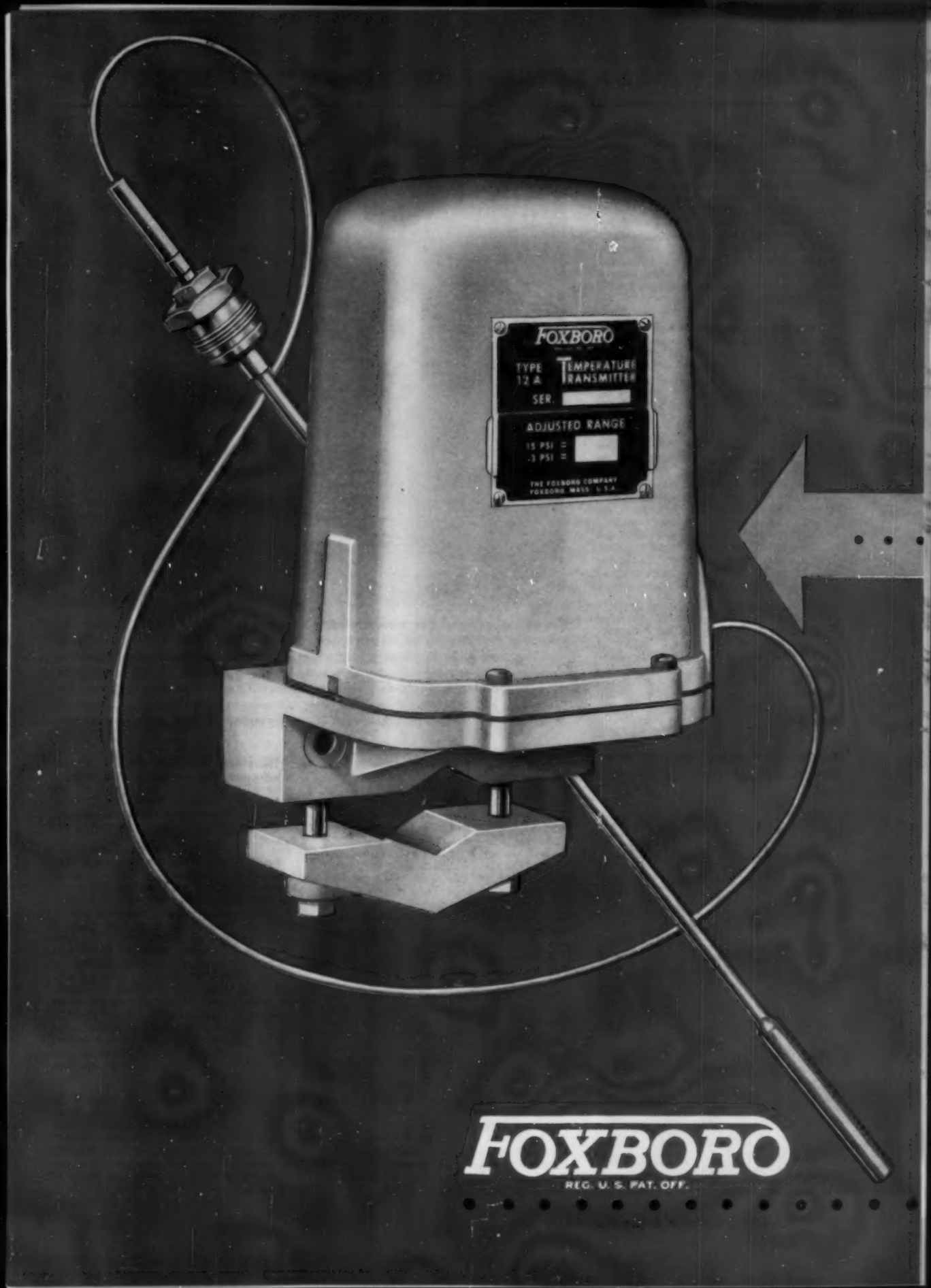
Joint Louisiana gasoline plant. A gasoline recovery plant is to be built by the Fluor Corporation for Union Oil & Gas Corporation of Louisiana and Texas Gas Exploration Corporation near Eunice, Louisiana. Plant will have capacity of 300,000,000 cu ft of gas daily, and will recover natural gasolint, commercial butane and propane. It will be in operation about June, 1957.

UOP to spend $1,000,000 for facilities. More than $1,000,000 has been appropriated by Universal Oil Products Company for additional process development facilities at its Riverside and McCook laboratories, and also at its Shreveport, Louisiana, manufacturing plant. No details of this program have been released.

Three units for G.P. refinery. A new Sovaformer, the second in this plant, a stove oil treater and a jet fuel treater are to be built by General Petroleum Corporation at its Ferndale, Washington, refinery. These are expected to be completed by the fall of 1957.

Bay to Dow? Plans for combining Bay Refinery Corporation with Dow Chemical Company in the Midland-Bay City area of Michigan, officials say. Dow has taken an option to buy the Bay company and its pipe line subsidiary. Dow will build a petrochemicals plant alongside the Bay plant, and the latter company will retain its identity and maintain operations as before, to produce gasoline, burning oils, and other petroleum products to supply its outlets in Michigan. Intermediate products from the refinery will be piped to the Dow plant to make petrochemicals, the chief product being ethylene for use of Dow plastics synthesis. The petrochemical unit will be in operation probably late in 1957.

Reformer for Everett. A 7200 B/D Powerformer unit for the Everett, Massachusetts, refinery of Esso Standard Oil is contracted for, with Badger Manufacturing Company. The unit will be completed by mid-1957, and will employ a new catalyst, which "utilizes small quantities of platinum."


FOXBORO
TYPE 12 A TEMPERATURE TRANSMITTER
SER.
ADJUSTED RANGE
15 PSI =
3 PSI =
THE FOXBORO COMPANY
FOXBORO MASS U.S.A.
FOXBORO
REG. U. S. PAT. OFF.

Rugged, Versatile Temperature Transmitter Improves Remote Control

. the Foxboro M/12A (pneumatic)

There is no easier, simpler way to measure remote temperatures, *fast*, over so wide a range, with such high sustained accuracy, and at so low a cost!

Between the limits of −100°F. and +1000°F., with operational spans of 50°, 100°, 200°, and 400°F, this rugged, highly responsive instrument performs outstandingly under the most severe conditions. It is compensated for ambient temperatures and pressure. Derivative action can be furnished for optimum performance when substantial thermal or transmission lags exist.

With its weatherproof housing and integral mounting bracket, it can be installed in any hazardous, corrosive, or outdoor location. Transmission lines are standard copper tubing, no electrical hazard, no costly capillary to run.

Write for Bulletin 13-17. It explains fully why the Foxboro M/12A Temperature Transmitter gives better performance with lower installation and maintenance cost. The Foxboro Company, 649 Neponset Ave., Foxboro, Mass., U.S.A.

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

• • Pneumatic Temperature Transmission

REFINING AND PETROCHEMICAL

PERSONALS

▸ **D. Woodson Ramsey Jr.** . . . . coordinator of the marketing operations of Standard Oil Company (New Jersey), elected to the board of directors of Jersey Standard's scientific affiliate, Esso Research and Engineering Company. He fills the vacancy created by **William R. Stott** . . . elected to the parent firm's board of directors last May.

Ramsey joined Esso in 1928 and by 1934 became president and manager of the West India Oil Company (Puerto Rico). Later he served in the Caribbean area, North Africa, and Central Europe. Earlier this year he was named to his recent position.

▸ British American Oil announced several key appointments in its manufacturing department. **M. T. Stevens** . . . . to manager of the Calgary refinery; **W. E. Lundie** . . . manager of the Clarkson, Ontario, refinery; **B. A. Barnhill** . . . manager of the Moose Jaw refinery, and **C. W. Coote** . . . manager of the Edmonton refinery.

Appointed as assistant managers are **D. G. Berry,** Clarkson refinery; **R. C. Beal,** Montreal East refinery; **R. M. Donald,** Edmonton refinery, and **H. A. Hornfelt,** Calgary refinery.

Stevens joined B-A in 1935, and since 1952 has been manager of B-A's Clarkson refinery. Lundie joined B-A at Moose Jaw refinery in 1934, where he has been manager for the past seven years. Barnhill with B-A since 1945 has been manager of the company's Calgary refinery, and Coote, manager at the company's Edmonton refinery, succeeds **R. T. Watson,** who is retiring after serving 36 years in the company's manufacturing department.

▸ **Robert S. Ray** . . . recently named vice president, elected to the Board of Directors and Executive Committee of Brea

Jack Tielrooy

R. S. Ray

Chemicals, Inc. He has been manager of manufacturing of Brea since 1953 and will continue in this capacity.

Jack Tielrooy . . . elected to the Board of Directors and Executive Committee of Brea, following his recent election as vice president. He will continue as Brea's manager of development.

▸ **Joseph W. Moorman** . . . appointed mid-continent district manager for James P. O'Donnell, consulting engineer. He was formerly associated with the M. W. Kellogg Company, and since 1947 has conducted his own practice as a consulting engineer.

▸ **W. Vaughn Ischie** . . . elected vice president and general manager of manufacturing, Sinclair Refining Company, succeeds **T. B. Kimball** . . . recently named director of manufacturing.

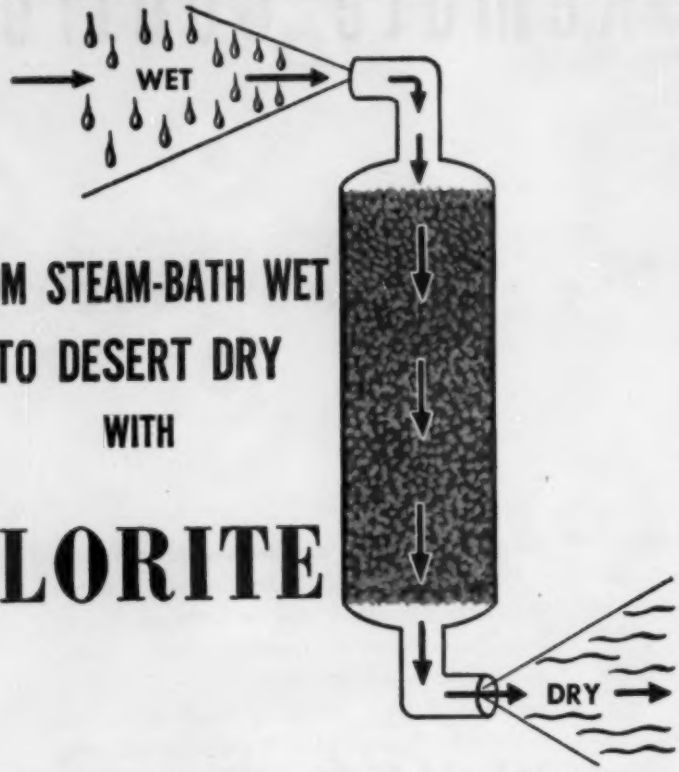
Ischie joined Sinclair in 1920 and in 1952 was granted a year's leave to accept the position of Director of the Foreign

R. C. Smith

W. V. Ischie

Refining Division of the Petroleum Administration for Defense in Washington, D. C. Returning to Sinclair in 1953, he was appointed assistant to the refineries manager.

Ray C. Smith . . . appointed manager of domestic sales, Sinclair Chemicals, Inc. Previously manager of market development he entered the Sinclair Research Laboratories in 1947.



FROM STEAM-BATH WET TO DESERT DRY WITH

FLORITE

Most economical of the granular drying agents, Florite has a longer service life, gives a low dew point depression, and aggressively resists "poisoning effects" which permanently destroy adsorption qualities.

Natural gas, propane, butane, gasoline, air, nitrogen, carbon dioxide, refrigeration compounds—and a growing list of liquid and gaseous compounds—are successfully treated with superior drying efficiency by use of FLORITE DESICCANT.

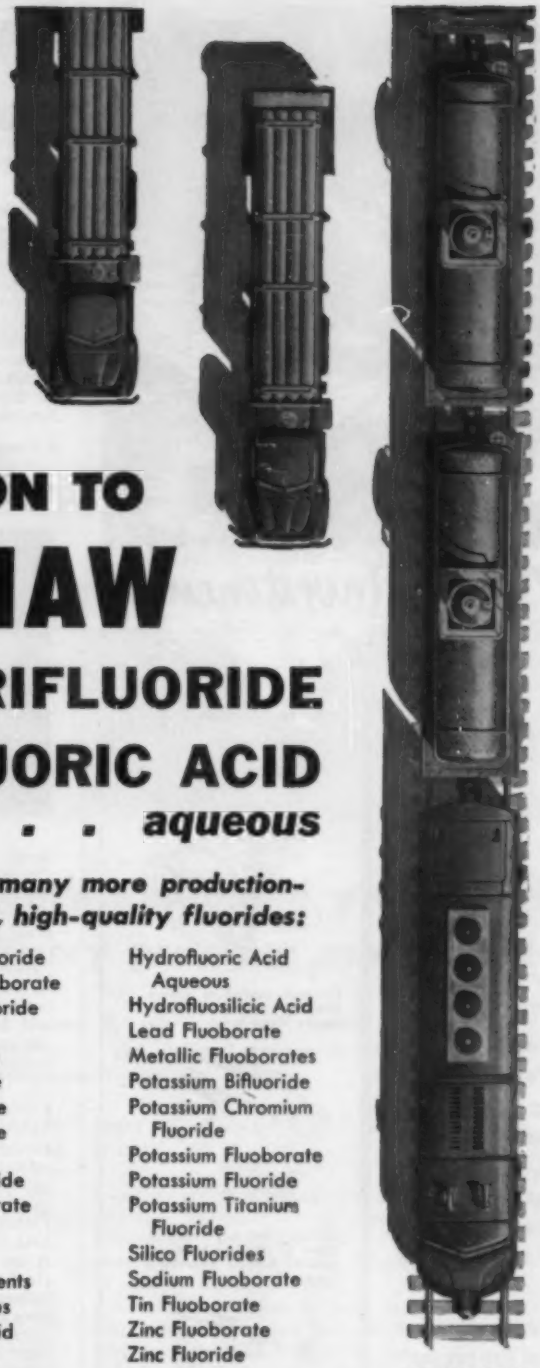
We also have available Fullers Earth and bauxite-based adsorbents for all types of adsorption filtration, including economical decolorization, dehydration and purification.

FLORIDIN COMPANY

Adsorbents
Desiccants
Diluents

Dept. D P.O. Box 989, Tallahasee, Florida

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



IN ADDITION TO HARSHAW

BORON TRIFLUORIDE
HYDROFLUORIC ACID
anhydrous . . . aqueous

Here are many more production-controlled, high-quality fluorides:

- Ammonium Bifluoride
- Ammonium Fluoborate
- Antimony Trifluoride Sublimed
- Barium Fluoride
- Bismuth Fluoride
- Boron Trifluoride
- Boron Trifluoride Complexes
- Chromium Fluoride
- Copper Fluoborate
- Fluoboric Acid
- Fluorine Cells
- Fluorinating Agents
- Frosting Mixtures
- Hydrofluoric Acid Anhydrous
- Hydrofluoric Acid Aqueous
- Hydrofluosilicic Acid
- Lead Fluoborate
- Metallic Fluoborates
- Potassium Bifluoride
- Potassium Chromium Fluoride
- Potassium Fluoborate
- Potassium Fluoride
- Potassium Titanium Fluoride
- Silico Fluorides
- Sodium Fluoborate
- Tin Fluoborate
- Zinc Fluoborate
- Zinc Fluoride

THE HARSHAW CHEMICAL CO.

1945 East 97th Street • Cleveland 6, Ohio

Chicago • Cincinnati • Cleveland • Detroit • Houston
Los Angeles • Hastings-on-Hudson, N. Y. • Philadelphia
Pittsburgh

WRITE FOR

Harshaw's 40-page Book on Hydrofluoric Acid Anhydrous. It provides helpful data.

Protect Your Capital Investment against Fire

...use spark-resistant Ampco Safety Tools in hazardous locations

Plants, equipment, and inventories cost a lot of money, but human life is priceless. With so much at stake, many companies rely on Ampco Safety Tools in hazardous locations, for protection and improved worker morale.

Ampco Safety Tools don't give off dangerous hot sparks. Yet, they are hard enough and strong enough to stand up under practical service conditions. Factory Mutual Laboratories and other safety authorities approve them for use wherever there are dangerous, inflammable liquids, explosive gases, dusts, or vapors.

An investment in Ampco Safety Tools pays big dividends in fire prevention. So protect your plant and your people—select the tools you need from more than 400 different items. Write for our new catalog ST-10.

AMPCO METAL, INC.
Dept. PE-9, Milwaukee 45, Wisconsin
West Coast Plant • Burbank, California
In Canada . . . it's Safety Supply Company, Toronto, Ontario

AMPCO®
THE METAL WITHOUT AN EQUAL

T-398

How to choose Safety Tools
For tools subject to impact and/or torque — specify Ampco Metal Tools.
For tools that have cutting edges or gripping teeth — specify Ampco Beryllium Copper Tools.
For tools to be used in the vicinity of acetylene or similar gases, specify Ampco Monel* Tools.
*T.M. International Nickel Co.

Personals

▸ **Richard C. Mathews**... joined the Davidson Chemical Company Division of W. R. Grace & Company, as a field service engineer in the petroleum catalyst department. He succeeds **John Benedict** ... transferred to the New York office. Mathews was previously with Standard Oil Co. (Indiana).

▸ **Richard T. Ozimek**... named supervisor of petrochemicals market research for Commercial Solvents Corporation. Previously a research chemist at Picatinny Arsenal, he most recently was market analyst with the National Aniline division of Allied Chemical and Dye Company.

William W. Wilson... named manager of terminals for the Petrochemicals Division of Commercial. With the company since 1936, Wilson will continue his headquarters at Sterlington, Louisiana.

▸ **George L. Parkhurst**... vice president and director of Standard Oil Company of California, recently received the Honor

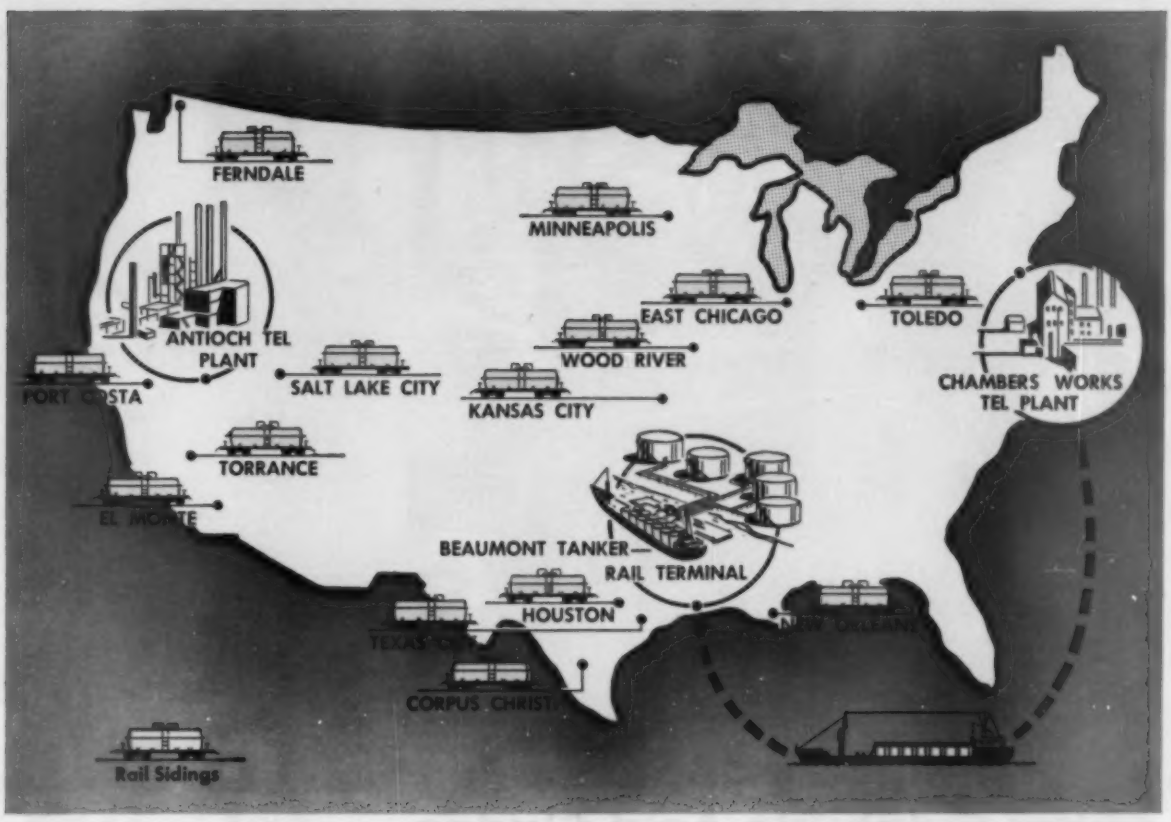
Scroll from President Thomas Rollins of the Western Chapter of the American Institute of Chemists.

The highest award that a Chapter can grant to a member of the chemical profession, the Honor Scroll was given to Parkhurst for "his outstanding integration of chemistry and administration in the petroleum and petrochemical industries; and for inspiration and guidance in his chosen field; and for his example of achievement to all chemists."

▸ Nine supervisors named to the staff at Tidewater Oil Company's new Delaware Flying A Refinery are: processing superintendents, **Raymond M. Camp,** former superintendent of alkylation and isomerization at Tidewater's Avon, California, Flying A Refinery; **Lloyd E. Forbes,** foreman of the catalytic cracking plant at the Avon refinery; **M. David Haynes,** former chief process design engineer at Bayonne refinery; **Robert M. Hunt,** former supervisor of the paraffin and lubricating department at Bayonne, and **E. L. Raun,** process superintendent and acting mechanical superintendent at Bayonne.

Robert B. Beattie, coordinator on the new refinery project, was named superintendent of engineering, maintenance, and construction. **R. S. Stanfield,** formerly chief engineer at the Bayonne Refinery, named refinery representative, and named superintendent of technology was **Dr. Arthur W. Lewis,** who headed the research laboratory at Bayonne. **Raymond Harrison Jr.** named superintendent of economic planning and accounting.

Walter J. Harrison... named assistant supervisor of employee relations, at the new refinery. He joined Tidewater in 1952 and has served as analyst in divisional employee relations department.



Du Pont's expanded production and delivery program moves ahead

West Coast TEL plant to go on stream by year's end . . . special tanker will transport TEL by sea for first time . . . new Du Pont storage and delivery terminal nears completion at Beaumont, Texas.

The Du Pont Petroleum Chemicals 1956 expansion program is nearing completion. It will meet increasing requirements, insuring ample TEL supplies and fast delivery service to refiners in all parts of the country.

On the West Coast

Du Pont's new TEL plant at Antioch, California, the most modern in the world, is now well over 50% complete. It is expected to go on stream by the end of 1956. Readily accessible to water, truck, and rail transportation, this means larger supplies and faster deliveries for West Coast refineries.

Gulf Coast

A tanker-supplied storage and delivery terminal is nearing completion at Beaumont, Texas. TEL will be transported from Du Pont's Chambers Works at Carney's Point, N. J., to Beaumont in a specially built tanker. This will be the first time TEL has ever been shipped in bulk by sea.

Upon inauguration of this service, Gulf Coast and mid-continent refineries will have additional assurance of ample TEL supplies.

Nationally

Refiners all over the country can benefit by Du Pont's increased TEL supply facilities including the many existing storage points throughout the nation.

DU PONT
REG. U.S. PAT. OFF.

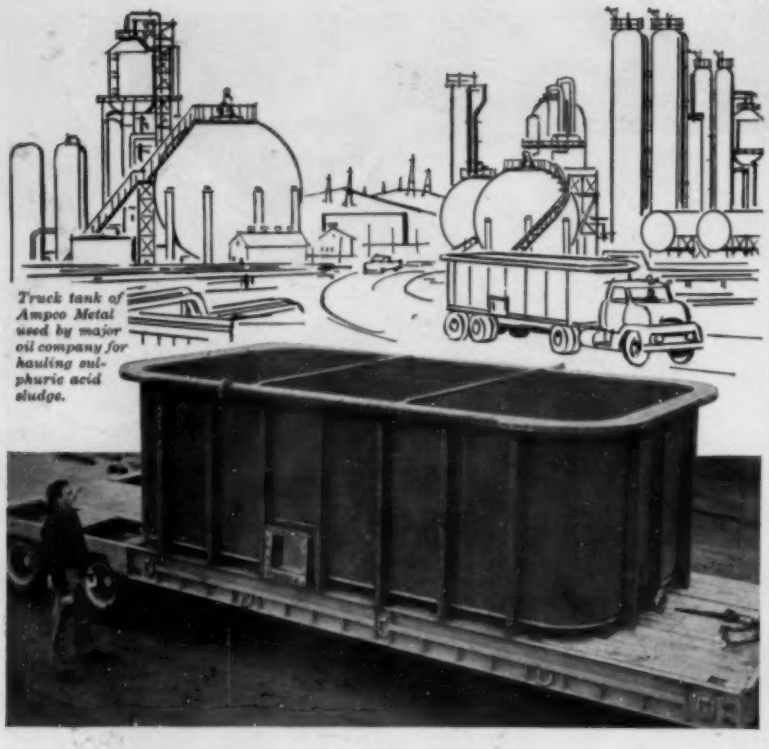
Better Things for Better Living
. . . through Chemistry

Petroleum Chemicals

Sales Offices: E. I. DU PONT DE NEMOURS & COMPANY (INC.) • Petroleum Chemicals Division • Wilmington 98, Delaware

CHICAGO 3—8 So. Michigan Ave. ..... RAndolph 6-8630
CLEVELAND 14—1321 National City Bank Bldg. ..... MAin 1-6460
HOUSTON 2—705 Bank of Commerce Bldg. ..... CApitol 5-1151
LOS ANGELES 17—612 So. Flower St. ..... MAdison 5-1691
NEW YORK 20—1270 Ave. of the Americas ..... COlumbus 5-2342
PHILADELPHIA 2—3 Penn Center Plaza ..... LOcust 8-3531
PITTSBURGH 22—Room 751, 1 Gateway Center ..... ATlantic 1-2933
SAN FRANCISCO 4—Room 626, 111 Sutter St. ..... EXbrook 2-6230
SEATTLE 3—Room 215, 4003 Aurora Ave. ..... MElrose 6977
TULSA 1—P. O. Box 730, 1811 South Baltimore Ave. ..... LUther 5-5578

IN CANADA: Du Pont Company of Canada Limited—Petroleum Chemicals—85 Eglinton Avenue East—Toronto 12, Ontario—HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division—Export Sales—Room 7496 Nemours Bldg.—Wilmington 98, Del.—OLympia 4-5121, Ext. 2962



Truck tank of Ampco Metal used by major oil company for hauling sulphuric acid sludge.

Handles 35% Solution of Hot Sulphuric Acid Sludge

Truck tank...made from Ampco Metal Grade 8 plate...resists corrosion

Ampco Metal resists corrosion, erosion, and cavitation-pitting caused by...

Boiling sulphuric acid (up to 50%)

Hot concentrated caustic solutions

Fatty acids

Hydrofluoric acids

Abrasive solids in suspension

Other problem liquids and abrasives

Ampco Metal has exceptional resistance to the destructive attack of many alkaline and acid media.

That's one reason why this aluminum-bronze alloy is used in fabrications like the truck tank shown here; in pipe, fittings, and other forms.

There are other reasons, also:

(1) Ampco Grade 8 can be readily sheared, bent, formed, or deep drawn.

(2) It is easy to weld with Ampco-Trode* by the metal-arc, carbon-arc, MIG or TIG processes.

(3) It possesses high impact and fatigue strength.

You can get Ampco Metal in sheet, plate, extrusions, sand and centrifugal castings, pipe fittings, fasteners, tubing, pumps, valves, etc.

Ask your Ampco field engineer for further facts — or write us. *Reg. U. S. Pat. Off.

AMPCO METAL, INC.

Dept. PE-9, Milwaukee 46, Wis. • West Coast Plants: Burbank, Calif.

THE METAL WITHOUT AN EQUAL

SAND CASTINGS

CAST FLANGES

FORGINGS

CENTRIFUGAL CASTINGS

EXTRUSIONS

CAST PIPE FITTINGS

FABRICATIONS

SHEET AND PLATE

MACHINED PARTS

PR-24

Personals

J. D. Walk

▸ **Joe D. Walk...** named manager of economics in the manufacturing department of American Oil Company. He joined the company in 1945 and in 1954 was promoted to New Orleans as manager of technical service in the manufacturing department of Pan-Am Southern.

▸ **J. W. Vaiden**... vice president in charge of manufacturing, and **J. S. Freeman**... vice president in charge of production, given the titles of senior vice presidents of the Skelly Oil Company.

▸ **Lester H. Barnes**... promoted by Continental Oil Company to superintendent of the Ponca City refinery. Presently assistant superintendent of the refinery, Barnes joined Conoco in 1928.

Loren D. Grubb... refinery superintendent, became regional manager of operations of Petroleum Chemicals, Inc.,

L. D. Grubb

L. H. Barnes

and **Wyatt L. Walker**... superintendent of the catalytic cracking division of the refinery succeeds Barnes. Grubb joined Continental in 1939 and Walker has been with Conoco since 1944, recently superintendent of the catalytic cracking division.

▸ **J. H. Forrester** succeeds **William B. Plummer** as president of Indoil Chemical Company, Standard Oil Company (Indiana) subsidiary. Forrester will also head up the new consolidated company which will take over Indoil and two other Standard Oil chemical subsidiaries later this year.

Plummer who has been with Standard Oil for 26 years, will become a private consultant in the petrochemical field with headquarters in New York City.

F. A. Upson... appointed chief engineer in the Standard Oil Company (Indiana) general engineering department. **Otis J. Thompson** succeeds Upson as assistant chief engineer in the process engineering division and **Wilbert J. Buxton** replaces Thompson as head engineer in charge of the lube oil and asphalt section.

Other changes at Standard (Indiana) technical service divisions at Whiting, Indiana, are: New section leaders **Robert O. McKinley,** refinery economics division; **Robert J. Austin,** heavy oils, asphalt and ammonia division, and **John H. Lovett,** light oils division.

William L. Nemec, refinery economics; **Robert H. Crowther** and **Francis J. Citek,** light oils, were appointed group leaders. **Robert W. Klipp** named general foreman of the anaiytical laboratory.

Harold M. Romig... chief engineer, process engineering division, general engineering department, Standard Oil Company (Indiana), has retired after 28 years of service. He will enter private practice as a consulting engineer in Chicago.

Inside story:

Valves may look alike on the surface. Their performance is another story. And the inside story of Powell Valves is that *every* Powell Valve has *Performance Verified.*

X-ray and gamma ray inspection—examining the very structure of the metal itself—are two of the many ways that Powell can make absolutely certain that Powell Valves will give *dependable* flow control.

Every part of every valve must pass rigid inspection. As a final step in manufacture, every Powell Valve is subjected to *an actual line test.* Because of Powell's pains-taking quality control, valve repair is cut to the minimum and plant shut down through valve failure is substantially reduced. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our COMPLETE *quality line* which has PERFORMANCE VERIFIED.

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

PERFORMANCE PV VERIFIED

FIG. 1503—150-Pound Steel Gate Valve.

FIG. 6003—Steel Gate Valve for 600 Pounds W.S.P.

FIG. 6061—600-Pound Steel Swing Check Valve.

POWELL VALVES

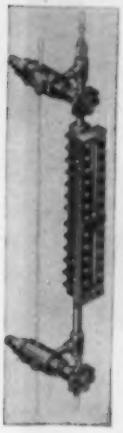
BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

How to Solve Problems of ACCURATE GAGING

of levels and pressures when liquids are

COLD and SLOW or HOT and FAST

Whether you handle liquids whose flow is "slow as cold molasses," or which boil and surge so they're hard to gage, Jerguson can solve your problems of accurate liquid level and pressure gaging.



Jerguson Heated or Cooled Gages

Specially designed to carry a circulating medium . . . heated to speed up the flow of slow, cold liquids . . . cooled to slow down boiling or surging liquids. Give you accurate liquid level readings, without tracing.

Jerguson Heated or Cooled Valves for Pressure Gages

Jacketed design with built-in tracing. Cold, heavy liquids flow so you get accurate pressure readings. Special design reduces threaded connections; combines unions, nipples, etc. in one compact unit. Ideal for cold services, waxes and other heavy materials.

Jerguson Gages and Valves now available with Electric Heating. Ask for special details.

Write for Data Units: #237 on Heat-Cooled Gages; #252 on Valves for Pressure Gages, etc.

JERGUSON

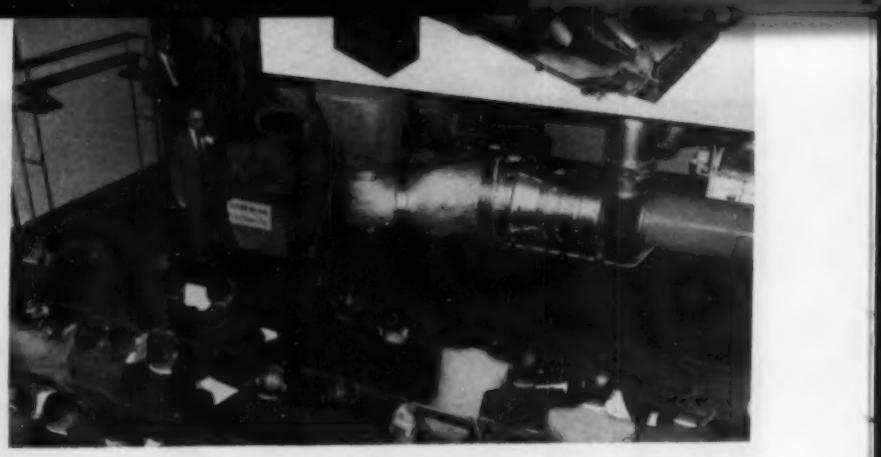
Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Offices in Major Cities

Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France



1000-hp Gas Turbine Introduced

GAS turbines for industrial applications rated in excess of 3500 horsepower have been in use in this country for some time. However units of lesser horsepower have not been available. A new gas turbine unit in the 1000 horsepower class has been introduced that is well suited to small installations, particularly where both power and process heating or steam are required. The unit is a simple, open-cycle dual shaft unit which is rated at 1130 bhp at 80F and 1000 ft elevation.

The compressor is a thirteen-stage axial flow unit having a compression ratio of 4:1 and a flow of approximately 22 lb of air per second.

The compressor operates at 11,500 rpm and the power turbine has a nominal output speed of 6000 rpm. For 50 or 60 cycle generator drive, a built-in planetary gear system can be provided to permit shaft speeds of 1500 or 1800 rpm.

The turbine driving the compressor as well as the power output or low pressure turbine are two-stage units. Turbines are designed to operate at an inlet temperature of 1340F.

Thermal efficiency of the unit based on the lower heating values is 15.1 per cent at full load. Efficiency at 75 per cent and 50 per cent of load is 13.4 and 11.0 per cent respectively. Where exhaust gases of the unit are used for steam generation or other heating applications, some reduction in power output is encountered due to the pressure drop through the heat exchanger unit. The following reductions in horsepower output are encountered under the various back pressure conditions.

Back pressure at site:				
Continuous rating, in. of water	2	4	6	8
Reduction at all loads, bhp	30	55	75	90

Protective devices incorporated in the unit include:

(a) Prevent turning over compressor on the starting motor without lube oil pressure at the bearings

(b) In the case of a gas-fired unit, they prevent ignition before the turbines, combustion chamber, and ducting have been purged with air from the compressor during normal starting cycle

(c) Shut down the unit automatically in the event of over-speeding or loss of lube oil pressure

This small turbine, designated as the Mark TA, will be manufactured and sold in this country by Clark Bros. Company, one of the Dresser Industries, under an agreement with Ruston-Hornsby Ltd., Lincoln, England.

ERNST

SIGHT FLOW INDICATORS

"See What Goes On Inside"

For insertion into pipe

FOR EVERY APPLICATION

BRONZE, IRON, STEEL, STAINLESS STEEL

FIG. 29 Cylinder with Impeller

FIG. 17-28 Cylinder

FIG. 215 Flanged

FIG. E-57 Double Window

FIG. 212 Visibility Welding Neck or Screw

FIG. E-811 Flapper

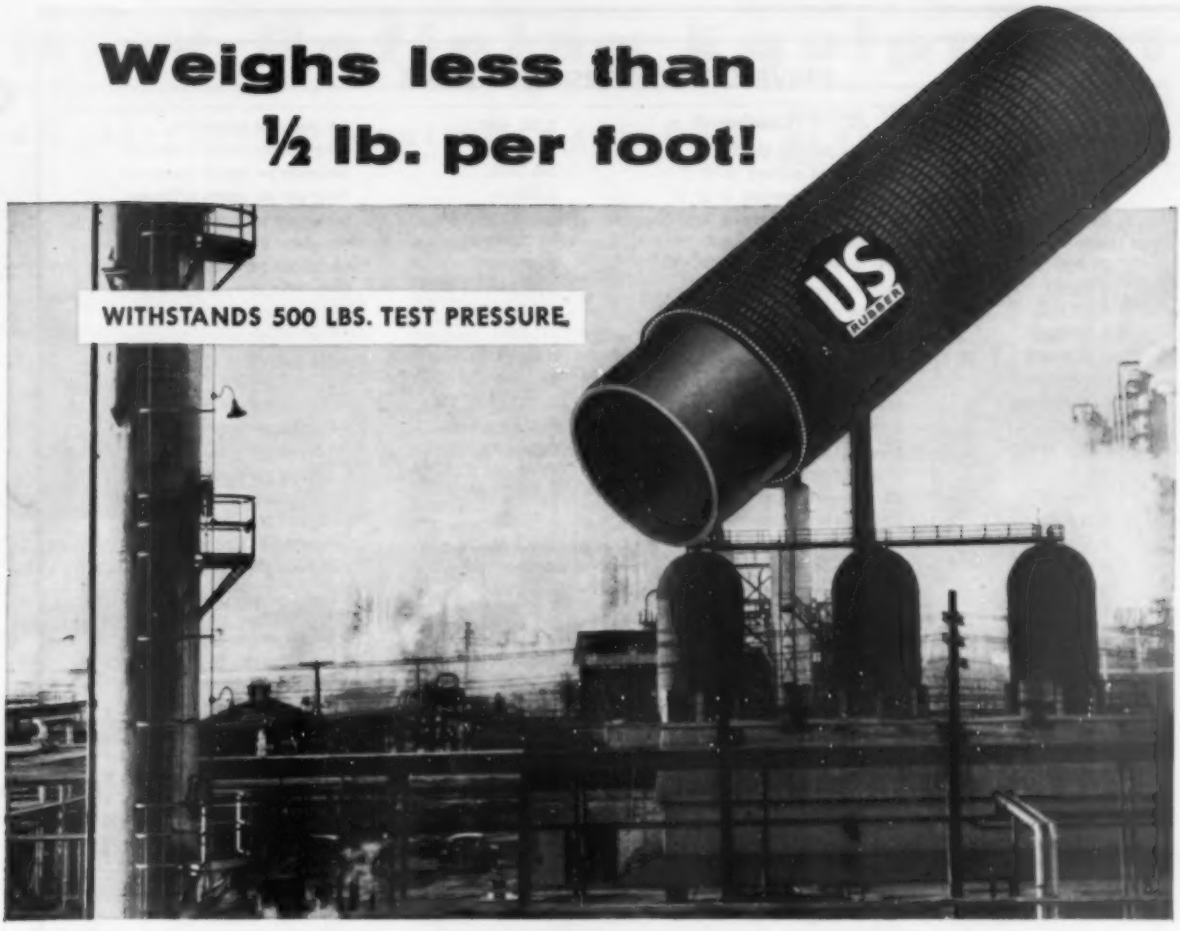
FIG. E-1810 Rotating Wheel Type

All sizes up to 6" *Send for Catalog*

ERNST WATER COLUMN & GAGE CO.

LIVINGSTON, N. J.

Weighs less than ½ lb. per foot!



The new super-flexible *All-Dacron*

U. S. FLEXLITE® FIRE HOSE!

Its single jacket is all Dacron*—to give the lighter weight, pressure resistance, flexibility, rackability required by today's petro-chemical fire departments.

Although U. S. Flexlite weighs 50% less than conventional hose, it will handle extreme pressures! Its Neoprene tube and Dacron jacket have the required resistance to chemicals, petroleum, mildew, dampness, heat. Coils easily, dries fast. United States Rubber Company also makes the following hose for the petro-chemical field.

(1) "Reliance®" Double Jacket Dacron reinforced (weighs 50 lbs. per 100 ft.) (withstands 400 lbs. test pressure)

(2) "Reliance" Double Jacket Dacron reinforced (weighs 54 lbs. per 100 ft.) (withstands 600 lbs. test pressure)

(3) U. S. Matchless® Carbolized—most rugged hose in the market.

Get in touch with any of our selected distributors or any of the 27 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, New York.

*DuPont's polyester fiber

US RUBBER

Mechanical Goods Division

United States Rubber

UNIVERSAL CONVERSION FACTORS

INCH OF MERCURY @ 32° F (Continued) =	
1	inches of mercury @ 32° F
0.254	decimeters of mercury @ 32° F
2.54	centimeters of mercury @ 32° F
25.4	millimeters of mercury @ 32° F
3806.515240	tons per square hektometer
38.065152	tons per square dekameter
0.380652	tons per square meter
0.0353645	tons per square foot
0.000245581	tons per square inch
0.00380652	tons per square decimeter
0.0000380652	tons per square centimeter
0.000000380652	tons per square millimeter
3,453,490	kilograms per square hektometer
34,534.9	kilograms per square dekameter
345.349	kilograms per square meter
32.0811278	kilograms per square foot
0.222786	kilograms per square inch
3.45349	kilograms per square decimeter
0.0345349	kilograms per square centimeter
0.000345349	kilograms per square millimeter
7,613,030	pounds per square hektometer
76,130.300609	pounds per square dekameter
761.303006	pounds per square meter
70.726441	pounds per square foot
0.491161	pounds per square inch
7.613030	pounds per square decimeter
0.0761303	pounds per square centimeter
0.000761303	pounds per square millimeter
34,534,900	hektograms per square hektometer
345,349	hektograms per square dekameter
3,453.49	hektograms per square meter
320.811278	hektograms per square foot
2.227864	hektograms per square inch
34.5349	hektograms per square decimeter
0.345349	hektograms per square centimeter
0.00345349	hektograms per square millimeter
345,349.000	dekagrams per square hektometer
3,453,490	dekagrams per square dekmetera
34,534.90	dekagrams per square meter
3208.112776	dekagrams per square foot
22.278639	dekagrams per square inch
345.3490	dekagrams per square decimeter
3.453490	dekagrams per square centimeter
0.03453490	dekagrams per square millimeter
121,808,481	ounces per square hektometer
1,218,085	ounces per square dekameter
12,180.85	ounces per square meter
1,131.623063	ounces per square foot
7.858573	ounces per square inch
121.8085	ounces per square decimeter
1.218085	ounces per square centimeter
0.0121809	ounces per square millimeter
3,453,490,000	grams per square hektometer
34,534,900	grams per square dekameter
345,349	grams per square meter
32,081.127762	grams per square foot
222.786665	grams per square inch
3,453.49	grams per square decimeter
34.5349	grams per square centimeter
0.345349	grams per square millimeter
34,534,900,000	decigrams per square hektometer
345,349,000	decigrams per square dekameter
3,453,490	decigrams per square meter
320.811278	decigrams per square foot
2,227.866675	decigrams per square inch
34,534.90	decigrams per square decimeter
345.3490	decigrams per square centimeter
3.453490	decigrams per square millimeter
345,349,000,000	centigrams per square hektometer
3,453,490,000	centigrams per square dekameter
34,534,900	centigrams per square meter
3,208,113	centigrams per square foot
22,278.666751	centigrams per square inch
345,349	centigrams per square decimeter
3,453.49	centigrams per square centimeter
34.5349	centigrams per square millimeter
3,453,490,000,000	milligrams per square hektometer
34,534,900,000	milligrams per square dekameter
345,349,000	milligrams per square meter
32,081,128	milligrams per square foot
222,786.667776	milligrams per square inch
3,453,490	milligrams per square decimeter
34,534.90	milligrams per sqaure centimeter
345.3490	milligrams per square millimeter
0.0338659	bars
0.0334214	atmospheres
3,383,845,567,678	dynes per square hektometer
33,838,455,677	dynes per square dekameter
338,384,557	dynes per square meter
31,460,290	dynes per square foot
218,474.233172	dynes per square inch
3,383,846	dynes per square decimeter
33,838.455677	dynes per square centimeter
338.384557	dynes per square millimeter
930.464111	feet of water @ 62° F and 29.92 Barom. Press.

INCH OF WATER @ 60° F =	
0.000254	hektometers of water @ 60° F
0.00254	dekameters of water @ 60° F
0.0254	meters of water @ 60° F
0.0833332	feet of water @ 60° F
1	inches of water @ 60° F
0.254	decimeters of water @ 60° F
2.54	centimeters of water @ 60° F
25.4	millimeters of water @ 60° F
0.0000186820	hektometers of mercury @ 32° F
0.00186820	dekameters of mercury @ 32° F
0.00186820	meters of mercury @ 32° F
0.00612925	feet of mercury @ 32° F
0.0735510	inches of mercury @ 32° F
0.186820	decimeters of mercury @ 32° F
0.186820	centimeters of mercury @ 32° F
1.868197	millimeters of mercury @ 32° F
279.973171	tons per square hektometer
2.799732	tons per square dekameter
0.0279973	tons per square meter
0.00260110	tons per square foot
0.0000180627	tons per square inch
0.000279973	tons per square decimeter
0.00000279973	tons per square centimeter
0.0000000279973	tons per square millimeter
254,000	kilograms per square hektometer
2,540	kilograms per square dekameter
25.4	kilograms per square meter
2.359600	kilograms per square foot
0.0163861	kilograms per square inch
0.254	kilograms per square decimeter
0.00254	kilograms per square centimeter

Compiled by Steven Gerolde, Gulf Oil Corporation.

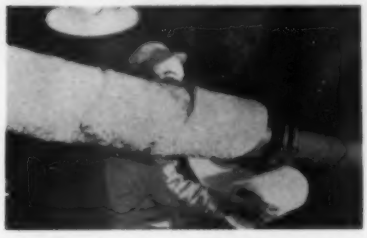
CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE

NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(41) Insulating Blanket. A high-temperature insulation blanket of Fiberfrax ceramic fiber, a material that resists temperatures as high as 2300 F, has been introduced by Carborundum.



Made of extremely fine, closely intertwining aluminum silicate fibers, the Fiberfrax blanket is claimed to keep its form and properties despite elevated temperatures.

The Carborundum Company.

(42) Remote Proportioning Control System. Sparton remote proportioning control system introduced offers high degree of flexibility in meeting remote process supervision problems.

Over one circuit, it both controls pilot proportioning operators and continuously monitors the changes that are produced.

Sparton Control Systems Division, The Sparks-Withington Company.

(43) Analysis of Gases and Liquids. A new model of its Vapor Fractometer (gas chromatography device) that permits fast analysis of gases and liquids boiling up to 300 C at operating temperatures up to 225 C, has been announced by Perkin-Elmer.

Instrument is designated the Model 154-B Vapor Fractometer, and incorporates several other new features. A precision liquid sampling system has also been developed as an accessory for the instrument.

The Perkin-Elmer Corporation.

(44) Reagent Pump. What is said to be the first completely corrosion-resistant reagent pump that will not be affected by the reaction of sulfuric, hydrochloric, and nitric acids in chemical plants is now being produced by Clarkson, using plastic parts manufactured by K-Plastix.

This feeder is capable of handling a top flow of 25 gal of any grade acid per hour without reaction.

The Clarkson Company.

(45) Laboratory High-Vacuum Still. A high-vacuum, brush-type still with high fractionating power is available from the Rochester Division of Consolidated Electrodynamics.

Designated Type 4010-01 Brush Still, this batch-type, laboratory unit separates heat-sensitive materials with molecular weights up to 900 at pressures as low as one micron Hg.

Rochester Division, Consolidated Electrodynamics Corporation.

(46) Chemical Process Pumps. For pumping most all chemical process liquids, either hot or cold, in moderate capacities against low, medium, or high heads, with special emphasis on a complete interchangeability of pump components, Peerless Pump Division has introduced chemical process pumps designated as Type DL and Type DM.

These pumps are offered in two basic designs: one is grease-lubricated designated as Type DL — the other is oil-lubricated designated as Type DM. Standard bearing construction for operation at temperatures to 250 F is grease lubricated. Above 250 F to 400 F oil lubricated construction is utilized.

Peerless Pump Division, Food Machinery and Chemical Corporation.

(47) Valve for Pilot Plants. An all-new stainless steel union bonnet globe needle valve designed specifically to solve the problems of pilot plant designers will be

shown by Hoke, Inc., at the Instrument Show in September.

Interchangeability of parts to satisfy widely varying operating conditions was the design objective for the new valve. This basic interchangeability means that a stock valve can be modified by the user to meet operating conditions varying from vacuum to high pressure, distilled water to corrosive fluids.

Hoke, Inc.

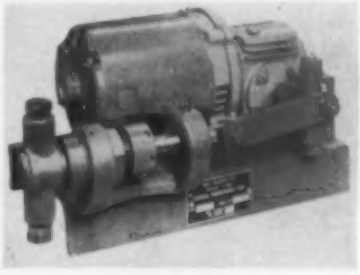
(48) Sealant for Thermocouple Gland. Announcement has been made of Lava Sealant in Conax Thermocouple Glands by Conax.

Lava Sealant, as used by Conax, is natural-fired magnesium silicate and is furnished in a preformed plug machined to fit into the sealant cavity of Conax glands whether the glands be of 1, 2, 4, 6, or 8-wire capacity. This sealant is compressed between two porcelain insulators under a pressure of 50,000 to 100,000 psi.

Conax Corporation.

(49) Chemical Feed Pump. A new chemical feed pump — Model 4411 — has been announced by Hills-McCanna.

A compact and simplified pump, Model 4411 has a maximum capacity of 7



gph/feed and discharge pressures up to 600 psi.

This pump is ideally suited for applications requiring precision and economy in the continuous feeding of chemicals used in water conditioning, chemical process additive feeding, petroleum inhibitor addition, and other similar applications.

Hills-McCanna Company.

(50) Electromagnetic Flowmeters. Nucor announces a line of electromagnetic flowmeters called Nucor Magnaflow.

Instrument converts liquid velocity directly into an electric potential without any inherent pressure drop and with high accuracy. It is adaptable to measure flow rates as low as 100 cc/min and as high as 2000 gpm.

Nuclear Corporation of America, Inc.

"But why can't I turn that bunch of cats into that cat cracker?"

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(51) Tray-Type Deaerator. A Cochrane publication describes a deaerator design guaranteed to provide complete deaeration.

Pamphlet tells how continuous maintenance of perfect heat balance eliminates waste of steam or heat, and how more heat can be recovered and returned to the boiler if exhaust steam is used, thereby effecting fuel savings.

Cochrane Corporation.

(52) Pneumatic Operators. Conoflow has issued a bulletin on pneumatic-spring and diaphragm operators.

Bulletin illustrates and describes Conoflow's Series B-10 and B-20 Spring and Diaphragm Conomotors, rugged versatile operators available from the factory in complete valve assemblies.

Conoflow Corporation.

(53) Asbestos-Cement Sheet Material, "J-M Asbestocite" is an illustrated, six-page folder issued by Johns-Manville explaining how this asbestos-cement sheet material can serve industry. Applications include the use of Asbestocite for cooling tower housings, cold storage room facings, a weather protection on insulated outdoor tanks, and for the construction of fume hoods and ducts.

Johns-Manville.

(54) Back-Pressure Control System. A bulletin on its Micro Delta P controller has been published by Industrial Engineering.

The Micro Delta P is a back-pressure control system complete in one unit, providing square-wave pressure response, micro-second control without hunting, and constant pressure throughout full-flow range.

Industrial Engineering Corporation.

(55) Manual and Automatic Valves. A 20-page, illustrated, color catalog has been published by P-K Industries on its line of manual and automatic valves, which are specifically designed for the tougher, more difficult problems in operation.

The Paul Venturi Ball valve design enables the valve to provide high capacity, erosion resistance, and to self purge.

P-K Industries, Inc.

(56) Integrally Finned Tubes. Wolverine Tube announces a booklet designed for many industries "Opportunities Unlimited — Using Wolverine Trufin."

This booklet covers a number of the numerous applications where Trufin (the Integrally Finned Tube) is used and can be used effectively and economically.

Wolverine Tube, Division of Calumet & Hecla, Inc.

(57) Anhydrous Aluminum Chloride. Solvay Process Division has issued a four-page bulletin on the chemical and physical properties of anhydrous aluminum chloride.

Given in the pamphlet are a typical analysis, properties, uses, grades, suggested handling methods, and precautionary information.

Solvay Process Division, Allied Chemical & Dye Corporation.

(58) Pressure Tubing. A four-page folder released by Babcock & Wilcox furnishes condensed data on the mechanical and physical properties of seamless and welded carbon steel pressure tubing.

It also supplies helpful information on the various fabricating operations normally performed on such tubing.

The Babcock & Wilcox Company.

(59) Dust Collector. The Ventrijet made by Pangborn for the wet collection of industrial dusts is illustrated and described in an eight-page brochure released by the company.

In the Ventrijet, utilizing the ventritube principle, water is broken into fine particles and mixed with dust-laden air without mechanical means in one or more venturi tubes. Dust entrapped in the water particles settles to the bottom of a tank built integrally with the collector for automatic, mechanical removal.

Pangborn Corporation.

(60) Complete Motor Line. A revamped bulletin that now includes a more complete line of U. S. motors is being released by U. S. Electrical Motors. Descriptions and full-color illustrations are included.

U. S. Electrical Motors, Inc.

(61) Large-Diameter Thin-Wall Tubing. What is said to be the first literature ever produced on large-diameter, thin-wall tubing has been prepared by Superior Tube.

Literature describes tubing in sizes with outer diameters from ⅝ to 2½ in. and with wall thickness of .035-in. and less.

Superior Tube Company.

(62) Direct-Acting Flow Rate Regulators. W. A. Kates now offers a six-page bulletin to explain the operation of direct-acting flow rate regulators and the best means of applying them.

Kates regulators are available in both gravity and spring-actuated models. Extreme accuracy of flow rate control, claimed, despite pressure fluctuations to 125 psi, recommend their use in blending and proportioning control where the liquid is fed from a gravity tank or centrifugal pump.

W. A. Kates Company.

(63) Rigid Unplasticized PVC Compounds. An eight-page bulletin on rigid, unplasticized polyvinyl chloride compounds Geon 8700-A and 8750 is announced by B. F. Goodrich Chemical.

Booklet deals specifically with the use of these compounds in manufacturing rigid vinyl pipe and fittings.

B. F. Goodrich Chemical Company.

(64) Standardized Instrument Panels. Now power and process plants can choose instrument and control panels to meet their individual specifications from six standard designs, according to a bulletin issued by Bailey Meter.

Completely tubed and wired, ready to "plug-in" on arrival, these panels and their accessory equipment are illustrated and described in this 16-page folder.

Bailey Meter Company.

(65) Corrosion Proofing. A revised edition of Pennsalt Chemicals' reference manual on corrosion proofing provides information on the latest developments in this field.

Included in the eight-page, illustrated manual are descriptions of the application of Corlok, an entirely new type chemical-resisting mortar recently introduced by Pennsalt.

Pennsylvania Salt Manufacturing Company.

(66) Chemical Mixing Without a Mixing Tank. Addendum No. 1 to Technical Supplement HM on the use of the "American" Homomix in continuous chemical mixing without a mixing tank has been published by American Well Works.

Addendum explains the operation of the Homomix as a continuous pipe line mixer and as a batch mixer, gives features and design data, including curves on size and capacity.

The American Well Works.

(67) Centrifugal Dust Collector. A bulletin on the recently developed Cyclo-trell multiple-tube dust collector has been issued by Research-Cottrell.

The 12-page illustrated bulletin explains the operation and construction of the Cyclo-trell, which is available in six sizes, ranging from 3 to 20 tubes.

Research Cottrell, Inc.

(68) Floating-Roof Storage Tanks. A catalog and data book on the patented "Tube-seal" System for floating-roof storage tanks has been published by Hammond Iron Works.

Illustrated catalog describes the design and construction of the improved Hammond Tubeseal — the only floating-roof seal that completely eliminates every space between seal and product, according to the manufacturer.

Hammond Iron Works.

(69) Welded Carbon Steel Tubing. A six-page folder has been released by Babcock & Wilcox on the quality, dependability and economy of electric resistance welded carbon steel tubing in applications involving heat transfer.

A chart outlining the hydrostatic test pressures required for the various sizes of tubes under ASTM A-214 is also shown.

The Babcock & Wilcox Company.

(70) Nitric Acid Plants. A four-page, two-color bulletin describes how efficient, low-cost production of nitric acid is possible.

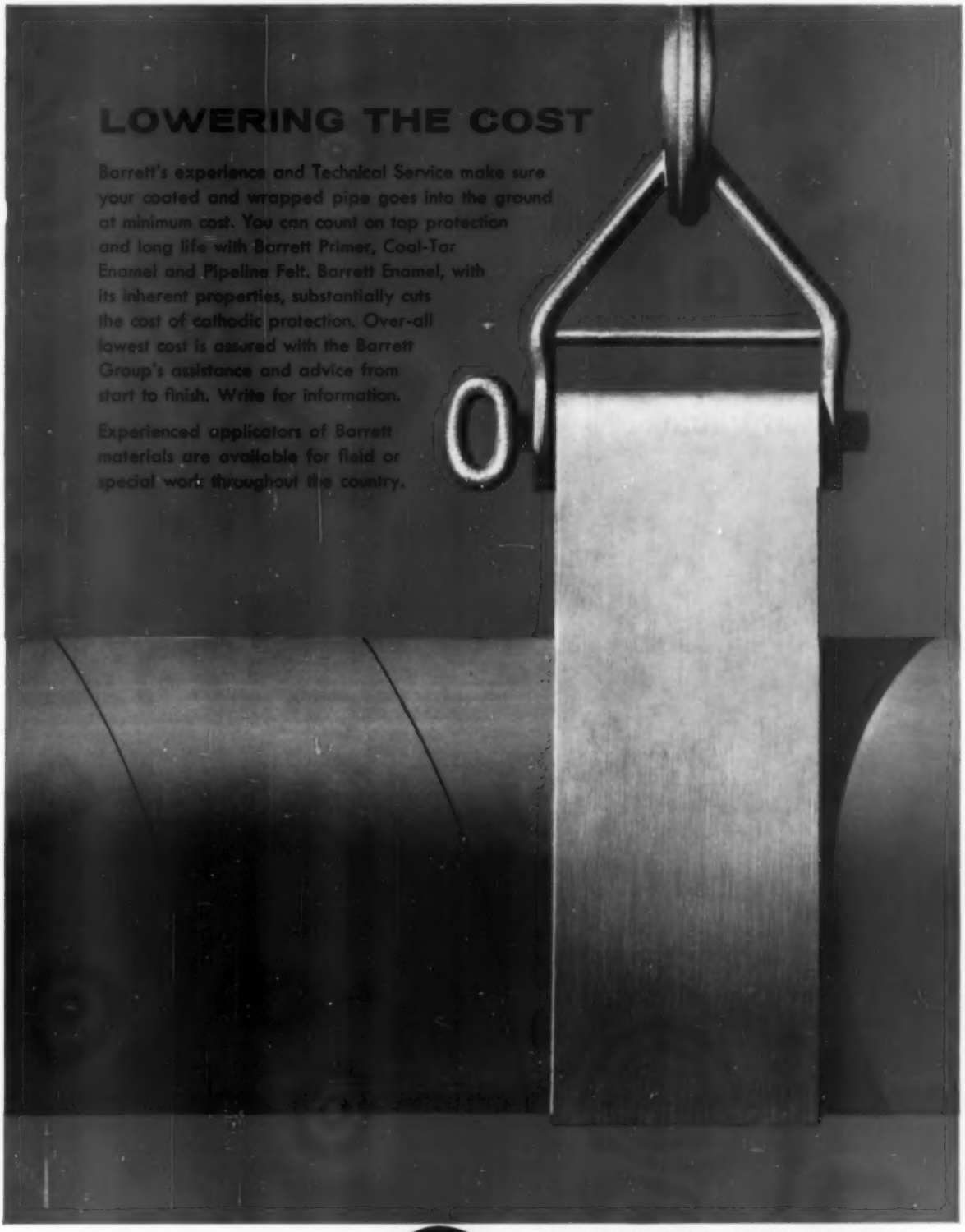
Typical operating requirements for the manufacture of nitric acid are included, along with a process description and simplified flow diagram.

The Fluor Corporation, Ltd.

(71) Thermocouples. A 40-page booklet published by Wheelco Instruments Division discusses construction and application of thermocouples and radiation detectors as used on industrial control applications.

Included as a portion of the Wheelco Data Book are standard thermocouple temperature-millivolt equivalents with temperatures being expressed on the International Temperature Scale of 1948. The electromotive force is expressed in absolute units.

Wheelco Instruments Division, Barber-Colman Company.


LOWERING THE COST
Barrett's experience and Technical Service make sure your coated and wrapped pipe goes into the ground at minimum cost. You can count on top protection and long life with Barrett Primer, Coal-Tar Enamel and Pipeline Felt. Barrett Enamel, with its inherent properties, substantially cuts the cost of cathodic protection. Over-all lowest cost is assured with the Barrett Group's assistance and advice from start to finish. Write for information.
Experienced applicators of Barrett materials are available for field or special work throughout the country.

Barrett®

PROTECTIVE COATINGS

BARRETT DIVISION, Allied Chemical & Dye Corporation, 40 Rector Street, New York 6, N. Y. In Canada: The Barrett Company, Ltd., 5551 St. Hubert Street, Montreal, Que.

Allied Chemical

OVER 100 YEARS OF EXPERIENCE

CHOICE of CONTACTORS

to meet your specific needs

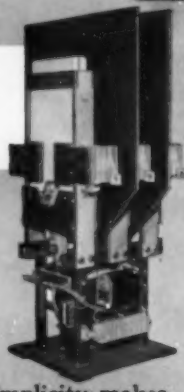
ALLIS-CHALMERS

Type H Starters

FOR 2300 TO 5000 VOLT MOTORS

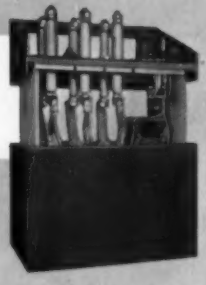
Allis-Chalmers Type H Starters may be equipped with either air-break or oil-immersed contactors —installed in the same sized space.

AIR



Designed for top performance on the rough-tough jobs. Advantage of contacts operating in air include long contact life, reduced fire hazard, easy maintenance. Double-break contacts, vertical action and dual blowouts provide long, dependable operation. Design simplicity makes contactor particularly adaptable for applications requiring frequent starting, inching, reversing, or dynamic braking.

OIL



Meets operating demands of semi-hazardous locations. Contactor operates under oil to prevent sparks from igniting atmosphere and to protect mechanism from corrosion. Contactor is time-proved clapper type. Self-cleaning, rolling-wiping action extends contact life. Self-aligning E-type magnet provides perfect armature seating . . . quiet, maintenance-free operation.

YOU GET MORE...

Allis-Chalmers offers help on specific control application problems. Call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by the experience gained in solving thousands of control problems . . . by complete research and testing facilities.

For complete information on the Type H starter, write for Bulletin 14B6410B — Allis-Chalmers, General Products Div., Milwaukee 1, Wis.

ALLIS-CHALMERS

A-4976

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

CRUDE LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	790	12–14	Guernsey, Wyoming to Coolidge, Arizona
Gulf Oil Corporation	33	8	Gathering lines from Citronelle, Alabama, field to Mobile
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to McPherson, Kansas
Northwest Pipeline Corporation, Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company, Houston, Texas	364	20	Offshore line in Gulf of Mexico from Sabine Pass to Mississippi River
Royal Dutch Shell Group and Others	870	30	Marseille, France, to Rotterdam and Antwerp, Holland
Sinclair Pipe Line Company, Independence, Kansas	150	20	Mexia to Houston, Texas. Replacement of existing line
	12	6	North Madill field to Cumberland field terminal, Oklahoma
Socony Mobil Oil Company de Venezuela and Sinclair Oil and Refining Company	211	20	From Silvester field, near Barinas, to Puerto Cabello, Venezuela
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Tecumseh Pipe Line Company	—	20	New line between East Chicago, Indiana, to Cygnet, Ohio
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon, Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3–6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	815	—	Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
	225	12–16	Junction station to San Francisco

PRODUCTS LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	60	8	Coolidge to Phoenix, Arizona
	70	8	Coolidge to Tuscon, Arizona
California-Oregon Pipe Line System, Crescent City, California	103	6	Crescent City, California to Medford, Oregon
Canadian Hydrocarbons, Ltd.	800	6-8	Alberta to Lakehead
Crescent Corporation, Tulsa, Oklahoma (LPG Line)	120	6	Tioga, North Dakota to U. S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
Malco Pipe Line, Inc., Roswell, New Mexico	91	6	Prewitt to Albuquerque, New Mexico
	138	6	Artesia to Newman, New Mexico
Northwest Pipeline Corporation, Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Phillips Pipe Line Company, Bartlesville, Oklahoma	50	12	Sweeny to Pasadena, Texas, refinery near Houston
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16–20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia. New gas facilities to replace this line have been completed but FPC order allowing removal from gas service has been remanded to FPC by a superior court order.
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U. S.-Canadian border to Winnipeg (See also Crescent Corporation listing)

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6–34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Yuni, Bolivia, through the Andes Pass, to Antofagasta, Chile
Carolina Natural Gas Corporation	185	2–12	Lines in North and South Carolinas
Cities Service Oil Company, Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland County, Texas
Coastal Transmission Corporation, Dallas, Texas	562	22–26	McAllen, Texas to Baton Rouge, Louisiana
	272	Var.	Gathering lines in Rio Grande Valley, Texas

CONSTRUCTION COSTS UP?

Here's how to save 20% in joining a pipeline

Armco Line Pipe is supplied in standard 50-foot lengths instead of the usual 40-foot or double-random lengths. This means at least 20 per cent fewer field joints. Line-up and welding time are reduced and you have fewer sections to handle.

What's more, the wide range of diameters—6 to 36 inches—and wall thicknesses—$\frac{9}{64}$ to $\frac{1}{2}$-inch—available in Armco Pipe allows you to use the right size for your particular requirements. No need to buy "oversize" pipe.

Use Armco Welded Steel Pipe for requirements in the Natural Gasoline and Natural Gas Divisions and wherever else you need dependable line pipe. Write us for data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 3956 Curtis St., Middletown, O. 201 KOME Building, Tulsa, Oklahoma. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Armco Welded Steel Pipe

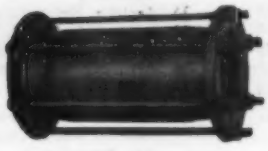
ARMCO

EMERGENCY STOCK WAREHOUSES need these...

TO SPEED AND SIMPLIFY PIPE LINE MAINTENANCE

It always pays to stock Dresser Repair Equipment up and down the line to save valuable time in making repairs. Furnished for pressures as high as 1000 lbs. or more, these products make short work of dozens of maintenance problems. Buy them direct or from our Houston or South San Francisco Warehouses. Write today for catalog.

Style 38



Style 40

DEPENDABLE CONNECTIONS

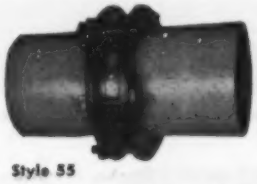
For fast connections and repairs, use time-proved Dresser Couplings and Long Sleeves. Ideal for replacing damaged sections of pipe and for tie-ins. Quick and easy assembly—permanently tight. Complete size range.

Style 93

Style 96

FOR BREAKS, SPLITS, HOLES

Dresser Split Repair Sleeves are a quick, efficient means of repairing breaks, splits, holes and other failures in pipe lines. Easy to install. No loose parts —no welding. Self-sealing end-gasket pressure increases as line pressure increases. Sizes 6" through 24".

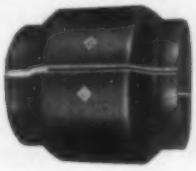


Style 55

TO REPAIR POROUS WELDS

Dresser Porous Weld Clamp stops leaks fast, without shutting down the line. Simply put it around the weld and draw up the bolts. You get a permanent repair in a matter of minutes. Sizes 2" through 31".

Style 110



Style 111

REINFORCING SLEEVES

Now available from Dresser in the best grade flange-quality steel plate. Uniformly perfect shaping assures easy installation. Vented against pressure build-up. Order Dresser Welding Sleeves for welded lines, Weld-over Sleeve for coupled lines. Can be furnished in special sizes and shapes when production quantities are involved.

DRESSER®

Dresser Manufacturing Division, 49 Fisher Ave., Bradford, Pa.
Warehouses: 1121 Rothwell St., Houston; 101 S. Airport Blvd., S. San Francisco. In Canada: 1211 Bathhurst St., Toronto; 1210 11th Ave., W., Calgary.

GAS LINES (Continued)

Name of Company	Miles	Size	Location
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6–8	Julesburg area to Denver, Colorado
	307	30	Main line between Idalia, Colorado and Beatrice, Nebraska
	160	26	Lateral between Carr, Colorado and Idalia
	75	26	Lateral between Kit Carson, Colorado and Idalia
	215	20-26	Parallel existing line between Texas and Oklahoma Panhandle gas fields and Kit Carson, Colorado
	34	16	Gathering lines from Keyes field, Oklahoma and Greenwood field, Kansas to new line
El Paso Natural Gas Company	108	4-20	Andrews and Ector counties, Texas
	888	—	Texas, New Mexico, Arizona
Houston Texas Gas & Oil Company, Houston, Texas	961	12–20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Iroquois Gas Corporation, Buffalo, New York	36	Var.	Gathering and delivery lines in underground storage area in Chautauqua, Cattaraugus and Erie Counties, New York
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	724	4–24	Loops on system in Missouri, Iowa; Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Midwestern Gas Transmission Company, Houston, Texas	1112	12–24	Main line from U. S.-Canadian Border near Emerson, Manitoba-Noyes, Minnesota to Portland, Tennessee
	648	3–18	Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Montana-Dakota Utilities Company, Minneapolis, Minnesota	41.8	12	Tioga-Beaver Lodge field in North Dakota to main transmission line
Natural Gas Pipeline Company of America, Chicago, Illinois	350	20–26	Fritch, Texas to Wise County, Texas, through Southwest Oklahoma
	398	36	Beatrice, Nebraska to Joliet, Illinois
	91	30	Loops in Nebraska, Kansas, Oklahoma
	25	—	Gathering line from Quinduno field Roberts County, Texas to a point on its existing system
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
New York State Natural Gas Corporation, Pittsburgh, Pennsylvania	27	—	Extend existing line from Elk County, Pennsylvania to new gas field in Clearfield, Jefferson, and Indiana Counties, Pennsylvania
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10–12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa, and Wisconsin
	100	20–24	Savanna Creek field, Alberta to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Co. (Subsidiary Northern Natural Gas Co.)	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Offshore Gathering Company, Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric, San Francisco, California	150	34	Loops on Topock, Arizona to Milpitas, California system
Permian Basin Pipeline Company, Omaha, Nebraska	19	16	Gathering system for 15 West Texas gas fields
Pioneer Natural Gas Company, Amarillo, Texas	261	3–22	New lines, loops, replacements and irrigation feeder lines in the Panhandle and South Plains of Texas
Shenandoah Gas Company, Winchester, Virginia	39	3–8	Middleton, Virginia to Martinsburg, West Virginia
Southern Counties-Southern California Gas Companies, Los Angeles, California	236	30	Topock, Arizona to Newhall, California. A 49-mile section of the line has been contracted, with remainder to be let in August
Tennessee Gas Transmission Company, Houston, Texas	100	—	New gathering lines in Texas and Louisiana
	162	26-30	Loops in Kentucky, Ohio, and Pennsylvania
Texas Eastern Transmission Corporation, Shreveport, Louisiana	422	30	McAllen to Vidor, Texas
	530	30	Loops on system from Texas to New Jersey
	180	Var.	Supply, lateral, and gathering lines
Texas Illinois Natural Gas Pipeline Co.	59	20	Joliet to Volo, Illinois
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14–24	Alberta area to Toronto, Montreal, and other eastern Canadian areas
Trans-Carolina Pipeline Corporation, Raleigh, North Carolina	840	2–18	New line between Moore, South Carolina, and Monroe, North Carolina, with laterals
Transcontinental Gas Pipe Line Corporation, Houston, Texas	277	30–36	Louisiana, Alabama, Georgia, South Carolina, North Carolina, Mississippi, Virginia, Maryland and Pennsylvania
Union Gas Company of Canada, Chatham, Ontario	180	—	Dawn Storage Field to Hamilton, Ontario
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia

Now Gilbarco offers a complete Electronic tank gauging system

100% MORE ACCURATE

This new Gilbarco Electronic Tank Gauge is a completely electronic device, NOT a float. It provides unmatched accuracy of measurement ± 1/16" at the tank base or remotely if desired.

100% AUTOMATIC

The Gilbarco Remote Receiver operates in conjunction with the Electronic Tank Gauge. It provides accurate readings of level and temperature on all tanks *from the instrument house.*

Here is complete AUTOMATION for your tank gauging. Five, ten, or fifty tanks — the New Gilbarco Electronic Tank Gauging System will handle the job accurately and automatically.

Gilbarco Tank Gauge is completely electronic . . . gauges tank levels to ± 1/16 of an inch . . . provides unmatched accuracy for all liquid measurement in all types of low pressure tanks.

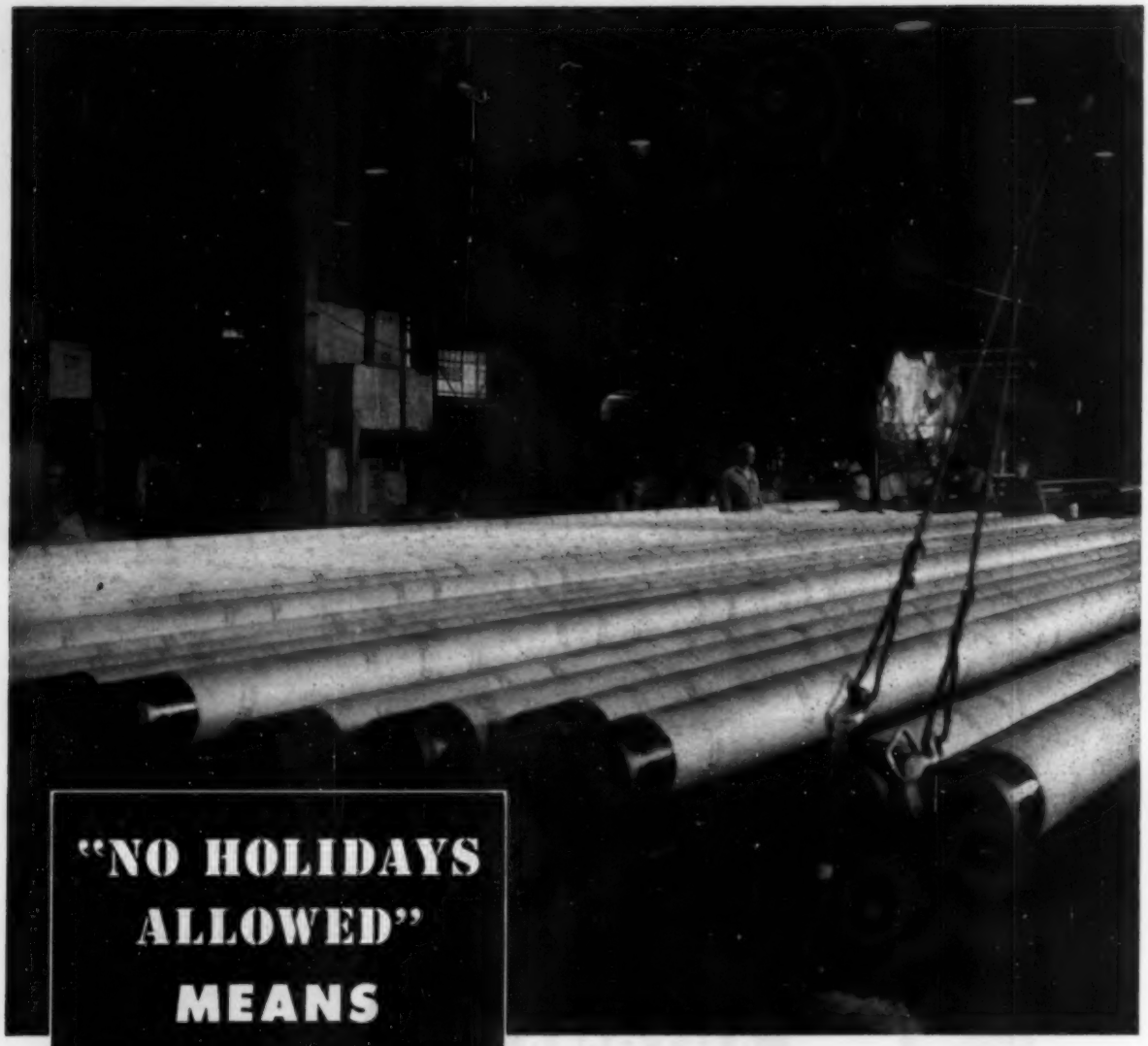
Gilbarco Gauges can be installed without taking tanks out of service. They are not affected by variations in specific gravity or viscosity. And they are provided with built-in checks for assurance of maintained accuracy.

Here is complete automation — for all tank gauging.

Save time and money on your tank gauging. Get all the facts on the new Gilbarco Tank Gauging System.

Write today for Complete Details

GILBERT & BARKER MANUFACTURING COMPANY, WEST SPRINGFIELD, MASS. • TORONTO, CANADA



"NO HOLIDAYS ALLOWED" MEANS BETTER PIPE PROTECTION!

When is a holiday not a vacation? When it's an imperfection in the coating and wrapping. Such a weakness cannot possibly escape detection at Hill, Hubbell. For in a final step, all Hill, Hubbell processed pipe goes on inspection skids as shown above. Then each square inch is carefully examined by an electronic Holiday Detector before the pipe leaves the plant. One of many quality controls developed by Hill, Hubbell, the use of Electronic Holiday Detectors is simply—

Another "first" pioneered by the first name in pipe protection

FACTORY APPLICATORS OF COATINGS AND WRAPPINGS

HILL·HUBBELL & COMPANY

DIVISION OF GENERAL PAINT CORP. • 3091 MAYFIELD ROAD, CLEVELAND 18, OHIO

COMPRESSION RING . . . 1-piece, quick-seating. Maximum strength. Turned finish on outside diameter lets ring conform readily to the cylinder bore. The chemically treated surfaces aid rapid seating, no scuffing or scoring during run-in. ½″ to 120″ diameters.

POROUS CHROME PLATED RING . . . exclusive Van der Horst process. Shallow porosity on cylinder contacting surface facilitates break-in, holds and distributes oil during this critical period. Lasts four times longer, cuts cylinder wear up to 75%. ½″ to 42″ diameters.

CONFORMABLE OIL RING . . . maintains constant pressure for positive oil control. Conforms to meet cylinder distortion; flexible cast iron member, pressed outward by abutment type spring exerts uniform radial pressure around entire circumference. 4″ to 25″ diameters, ¼″ min. width.

KOPPERS SEAL RING . . . has one or two projecting bands of bearing bronze inserted in contacting face. Very quick-seating. Tends to prevent blow-by in new or worn cylinders. The burnishing action of bronze on cylinder walls decreases scuffing and wear. 2″ to 30″ diameters.

GROOVED OIL CUTTER RING...valuable where oil control is a major problem. Two bevels for riding over oil on up-stroke, two scraping edges for removing excess oil from walls on downstroke, plus a series of wide drainage slots. 1½″ to 25″ diameters.

Five Koppers Rings . . . worth their weight in gold!

What will American Hammered Industrial Piston Rings *do for you?* They'll save you money on fuel, on lubricating oil, on labor costs—by reducing down-time.

They'll maintain high compression, improve your operation, give you *much* longer service. They don't cost much . . . but they have over 35 years of manufacturing skill and accumulated experience behind them. They never let you down, they never fail in the jobs they're designed to do—and hundreds of satisfied users will tell you that, despite their low cost, Koppers rings *are* worth their weight in gold.

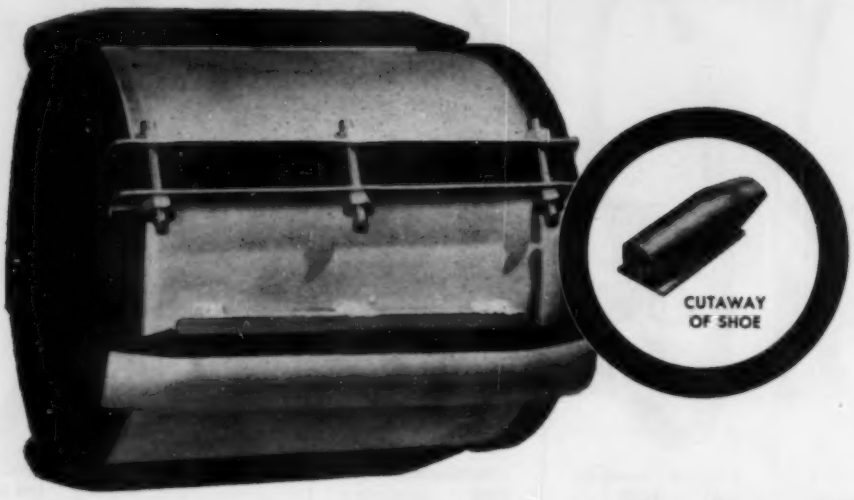
American Hammered Piston Rings are available in all types, all sizes—from ½″ to 10′ diameter—for every purpose. Koppers makes American Hammered Rings for all kinds of industrial equipment, can recommend without bias as to types. It costs nothing to consult Koppers—for illustrated Piston Ring booklet write to KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.,* 1709 Hamburg Street, Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore 3, Maryland
This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromotor Fans, Gas Apparatus.
Engineered Products Sold with *Service*

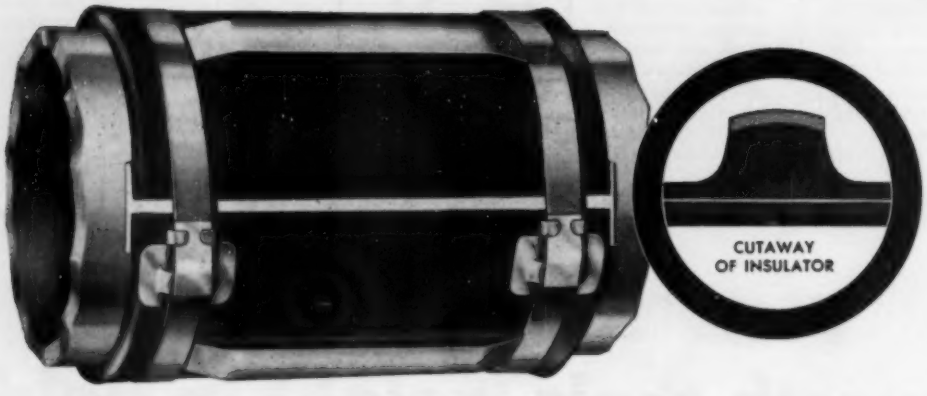
KOPPERS

AMERICAN HAMMERED
Industrial Piston Rings

Model 55 Maloney Insulators for LARGE JOBS



Model 56 Maloney Insulators for Small Jobs



Maloney Insulators for *Every Job!*

Maloney Crossing Insulators for pipeline casing are exceptionally rugged, easy-to-install . . . *and adaptable to a wide range of pipe sizes and differentials.*

Because they are bonded metal-to-neoprene-to-metal, Maloney Insulators provide good shock-absorption, plus flexibility to compensate for pipe shifting.

Streamlined "sled-type" steel runners make for easy entry into the casing, and prevent hanging-up on casing welds as pipe is being run.

Model 55 Maloney Crossing Insulators, in all sizes through 36", are fitted with an extra-wide steel band for positive grip. Model 56, for pipe size differentials from 2" to 12", are fastened to the carrier pipe with stainless steel bands. Both types offer greater dependability—greater protection against corrosion with high dielectric strength neoprene, and against physical damage with steel runners—than any other insulator on the market. Maloney Crossing Insulators are in use on most of the country's major pipelines.

"Something from the Irishman"

F. H. MALONEY *Company*

2301 TEXAS AVE. • FA 3-3161 • HOUSTON

SINCE 1932 — PRECISION IN RUBBER — METAL — PLASTICS

Every station on the Badger Pipeline uses Brown instruments

An operator checks a Brown ElectroniK temperature recorder at the Des Plaines metering station of the Badger Pipeline Co. Also on the panel are interlocked Brown flow and pressure controllers, and a Nelson specific gravity meter, which transmits to an ElectroniK strip chart recorder. A dispatcher at this station supervises product flow for the entire system.

Des Plaines, Ill. metering station of the Badger Pipeline Company. The company is owned jointly by Sinclair Pipeline Co., Cities Service Oil Co. (Del.), The Texas Co., and the Pure Oil Company.

AT metering stations, at pumping stations . . . all along the Badger Pipeline . . . Brown instruments keep close watch over temperature, pressure and flow. The Badger Pipeline system serves an area surrounding metropolitan Chicago and northwest to Rockford, Ill. and Madison, Wis.

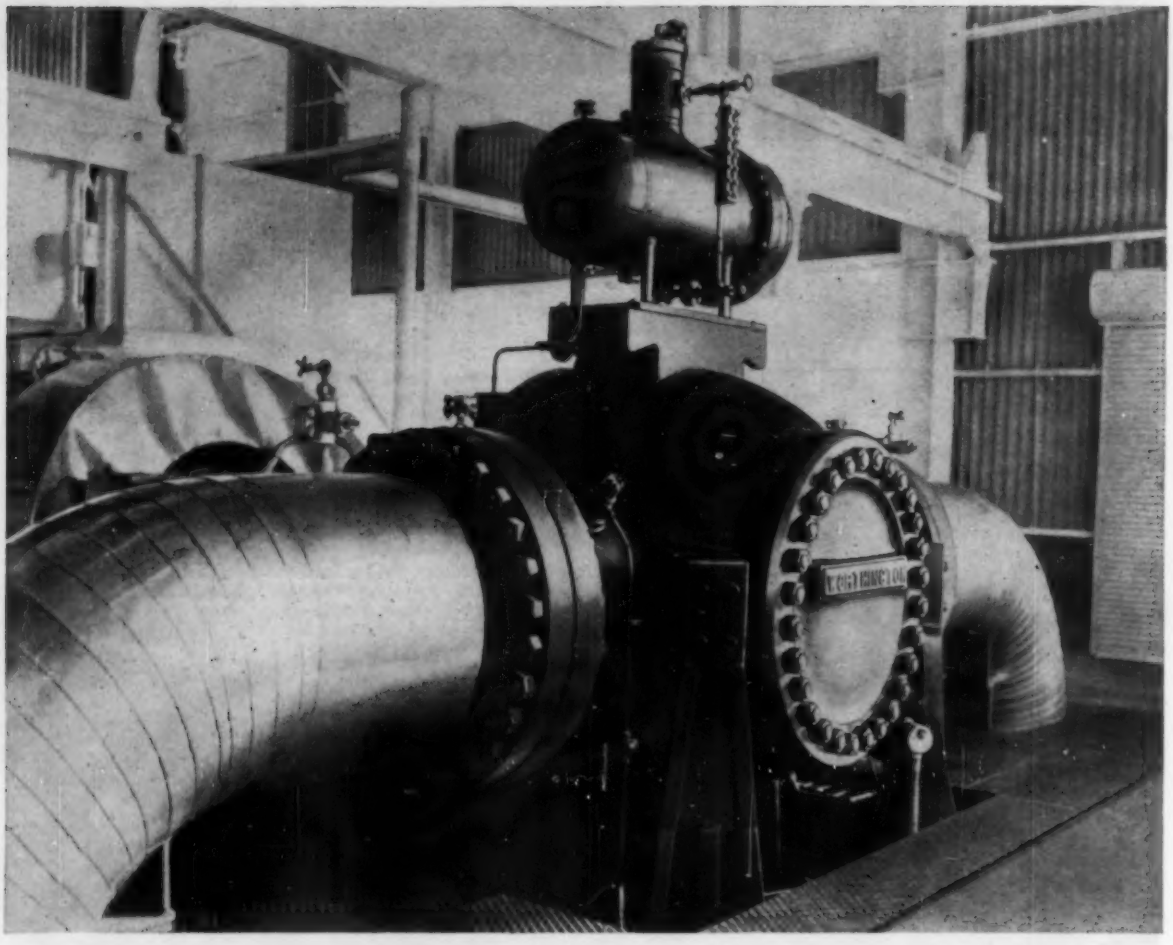
At the Des Plaines metering station shown above, *ElectroniK* recorders provide accurate temperature and specific gravity information. A Pressure Controller is interlocked with a Flow Controller to position the station control valve. Flow controller input is received from a mercuryless *Differential Converter* transmitter.

Accuracy, sensitivity, and "built-to-take-it" construction make Brown instruments ideally suited for pipeline operations everywhere.

For a discussion of your own pipeline applications, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



First "Center Line" Centrifugal Booster completes 18 months of pipeline service

Records show "practically no maintenance required"

This "new design" gas pipeline compressor has more than lived up to its advance billing. In service at Northern Natural Gas Company's Macksville, Kansas, station, since December, 1954, it has averaged 800 million cubic feet per day at a pressure of 500 psi. Records show that it has required practically no maintenance.

A brand new idea in compressor design, Worthington's type GUP compressor has a spherical casing supported at the center line. As a result, shaft distortions are minimized, starting stresses reduced, and bearing life extended.

A separate compressor driven pump supplies oil pressure at all times. By adding a cooler, the system may be made completely independent of the driver. A double trap in the scavenging system insures that no seal oil will seep into the gas stream.

It's easy to inspect. No internal part is too heavy for one man. The lightweight impeller, for example, weighs only 100 lbs.

If you'd like more information about this new pipeline compressor, write for bulletin C-1100-B57 to Section E66, Worthington Corporation, Harrison, N.J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ontario. E-6-6

WORTHINGTON

Do You Know

What Topaz Can Do For You?

Topaz is a sales and service organization offering you complete lines of nationally recognized pipeline supplies and equipment plus the consulting and supervisory services of experienced engineers. You can call Topaz night or day, with assurance that your needs will receive prompt personal attention.

Hot Tapping

Topaz* sales engineers plan and supervise** hot tapping operations on gas, steam, water, products and chemical lines without costly shutdown. Hot tapping equipment may be contracted, leased or purchased. Topaz service includes consultation, supervision and instruction of company field personnel on use of purchased equipment.

Agent for T. D. Williamson, Inc.
***In Cooperation with T. D. Williamson, Inc.*

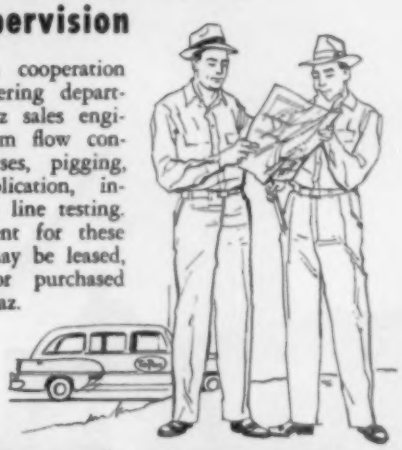
L & M Marker-Vents

L & M Marker-vents on highway and railroad casing vent pipes have proved both effective and economical. Less expensive than a field-welded vent hood, the aluminum alloy L & M Marker-vent will last the life of the line. Custom designed sign panels with your company name and emblem are available in your choice of colors. Sizes available for 2", 3" and 4" pipe. L & M products, distributed by Topaz* also include standard safety signs, well markers and aerial view markers.

**Sole distributor for L & M products.*

Consulting, Engineering and Supervision

Working in cooperation with engineering departments, Topaz sales engineers perform flow condition analyses, pigging, stopple application, inspection and line testing. All equipment for these operations may be leased, contracted or purchased through Topaz.



Cathodic Protection

All cathodic protection equipment and supplies, including rectifiers, anodes, coke breeze, pipe wrap and pipe coatings are available from one supplier . . . Topaz . This means savings to you in time and paper work.

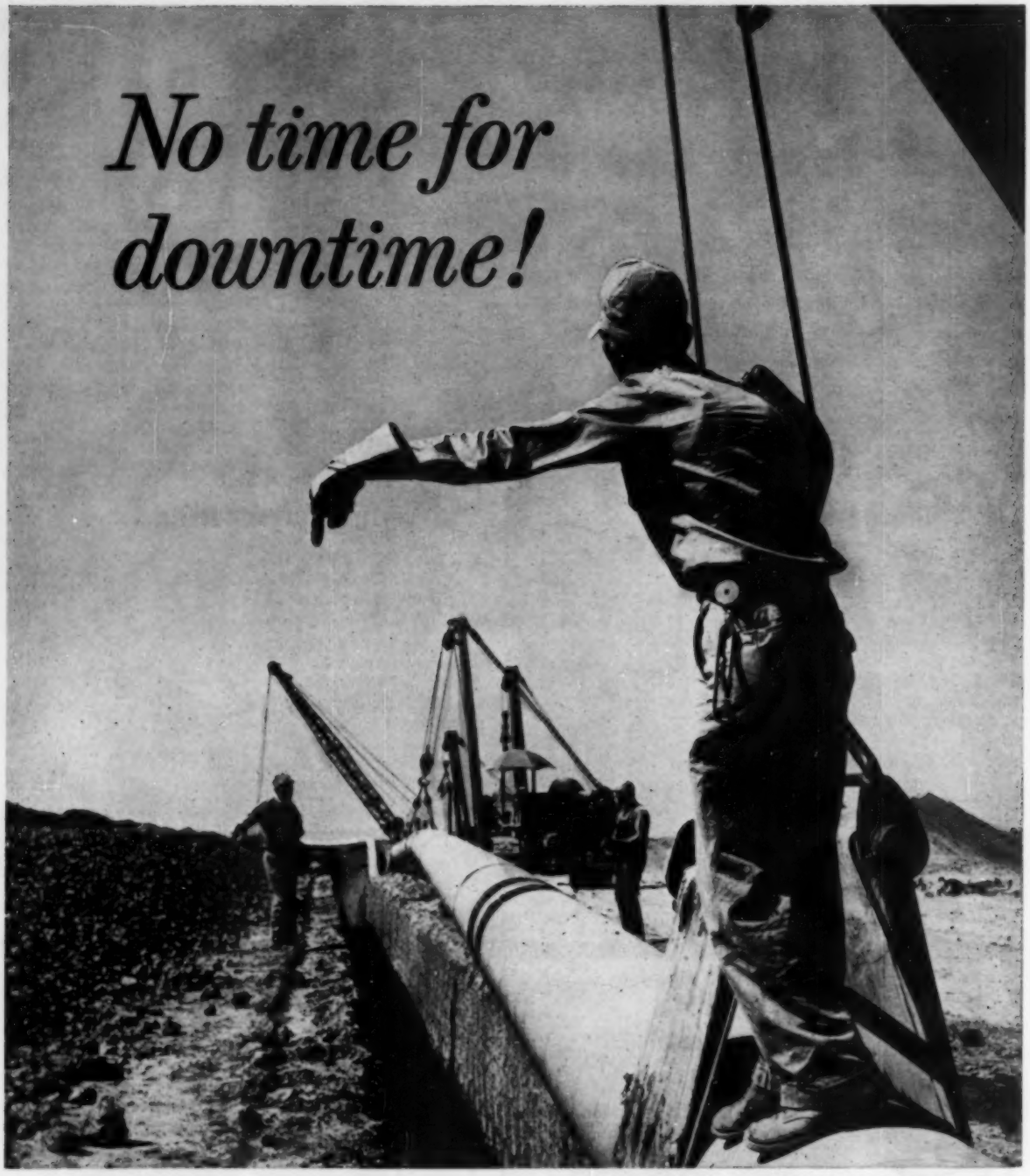
Other supplies available from Topaz:

- valves
- pipe cutting machines
- cutting and beveling machines
- odorizers
- clamps, hooks and dollies
- pipe saddles and reducers
- heavy machines
- torches
- Plus all other equipment or supplies necessary to complete your project.

Tod Pazdral *Pipeline Specialties*

TOPAZ

2525 South Boulevard Houston, Texas Office Phone: JA 2-1403
Tod Pazdral Consulting and Supervision Home Phone: MA 3-5680



PACIFIC NORTHWEST PIPELINE CORPORATION PHOTOGRAPH.

Staying on schedule is absolutely essential on a pipe line job.

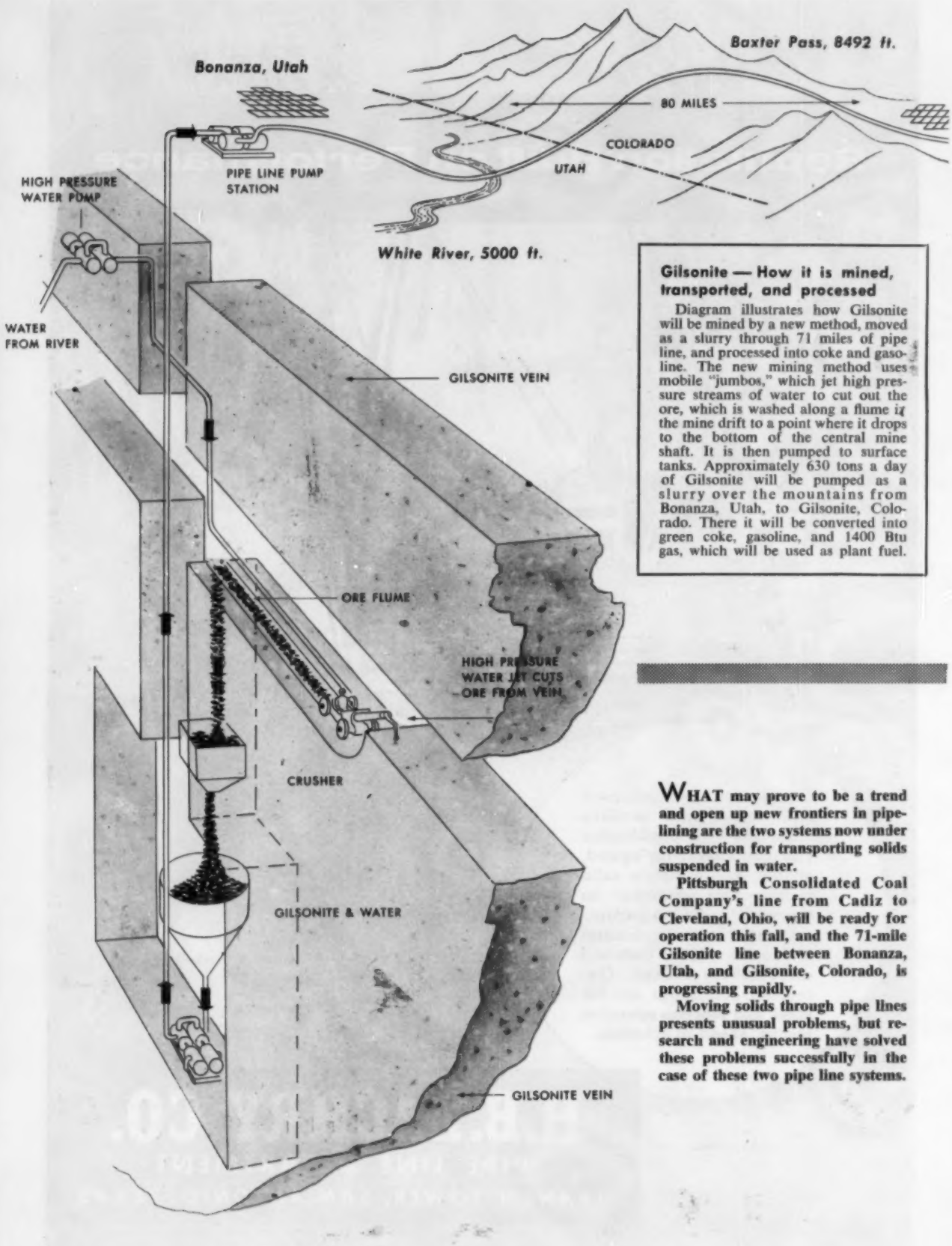
That's why so many pipe line builders depend on Kaiser Steel for quality pipe to meet API specifications—*delivered as scheduled.*

Next time you are ordering line pipe, specify Kaiser Steel Line Pipe. Rely on Kaiser Steel quality and service to add dollars to your operating profits.

Kaiser Steel

Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes semi-finished steels • pig iron • ingot molds • coke by-products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • Los Angeles • Oakland • Seattle • Portland • Phoenix • Denver • Tulsa • New York

Reputation Built on Performance
Experienced crews, adequate equipment, and modern know-how — a combination you can't beat for speed, quality, and complete satisfaction. Our reputation for top-notch, on-the-job performance, at bid price, eliminates undue construction costs and unnecessary delays. Our contract obligations are fulfilled, and pipeline operation begins, ahead of schedule.
H.B. ZACHRY CO.
PIPE LINE DEPARTMENT
TRANSIT TOWER, SAN ANTONIO, TEXAS



Gilsonite — How it is mined, transported, and processed

Diagram illustrates how Gilsonite will be mined by a new method, moved as a slurry through 71 miles of pipe line, and processed into coke and gasoline. The new mining method uses mobile "jumbos," which jet high pressure streams of water to cut out the ore, which is washed along a flume in the mine drift to a point where it drops to the bottom of the central mine shaft. It is then pumped to surface tanks. Approximately 630 tons a day of Gilsonite will be pumped as a slurry over the mountains from Bonanza, Utah, to Gilsonite, Colorado. There it will be converted into green coke, gasoline, and 1400 Btu gas, which will be used as plant fuel.

WHAT may prove to be a trend and open up new frontiers in pipelining are the two systems now under construction for transporting solids suspended in water.

Pittsburgh Consolidated Coal Company's line from Cadiz to Cleveland, Ohio, will be ready for operation this fall, and the 71-mile Gilsonite line between Bonanza, Utah, and Gilsonite, Colorado, is progressing rapidly.

Moving solids through pipe lines presents unusual problems, but research and engineering have solved these problems successfully in the case of these two pipe line systems.

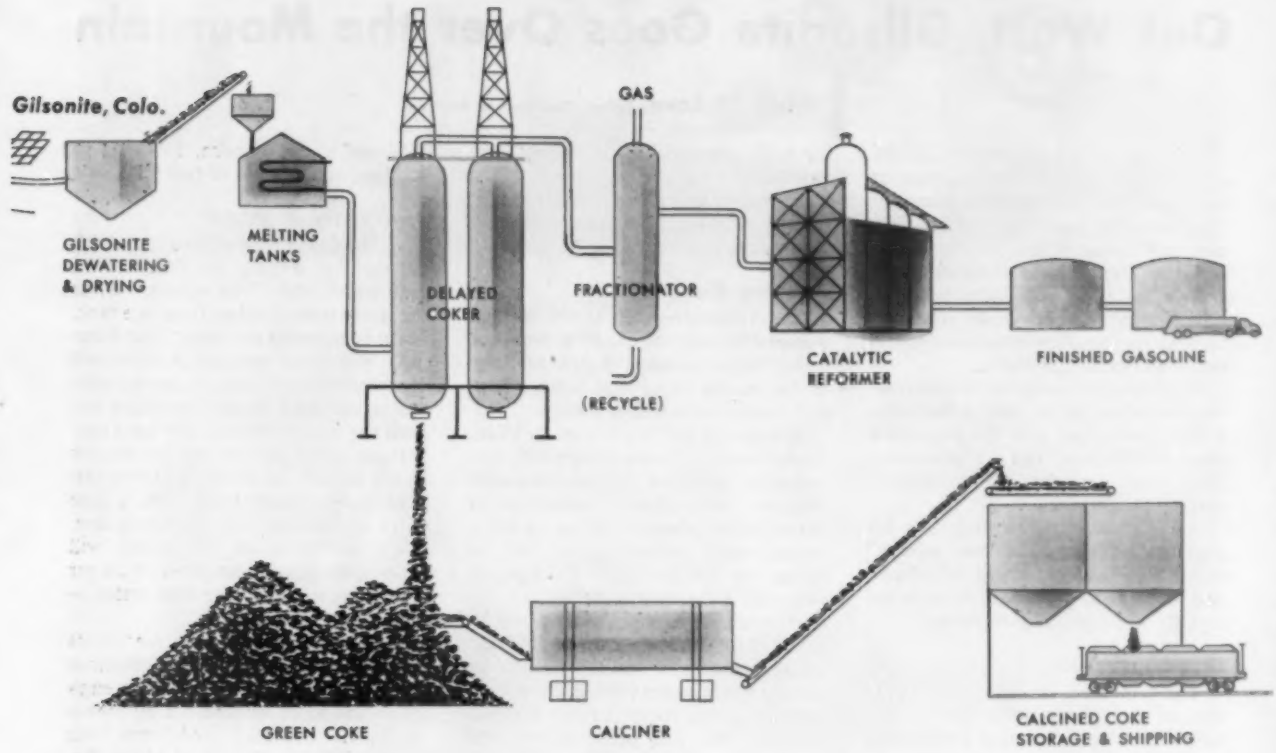


Diagram courtesy *The Standard Oiler*

SLURRY HANDLING:

New Frontier For Pipelining Operations

Solids suspended in water and moving by pipe line — exemplified by two new projects — are forerunners to challenging new areas for future pipe line developments

Out West, Gilsonite Goes Over the Mountain

Frank H. Love, *Editor, The Pipeline Engineer*

Gilsonite is a registered trademark of the American Gilsonite Company of Salt Lake City. The scientific name for this naturally occurring solid hydrocarbon is Uintatite, and principal veins are in the Uintah Basin of eastern Utah and western Colorado. The mineral can be converted into high purity electrolytic coke for the aluminum industry and into high octane gasoline.

Facilities now in course of construction for mining the product at Bonanza, Utah, transporting it to the processing plant at Gilsonite, and the processing plant itself, represent an undertaking costing $16,000,000.

A big feature of the project is the pipe line, although the "wet mining" techniques that are being introduced and the unusual processing features are equally as unique in their fields.

Line Construction

The 6-in. line, in adidtion to being one of the longest pipe lines in the world for transportation of a solid mineral, traverses some of the most rugged, uninhabited mountain terrain found anywhere. It will cross an 8492-ft mountain pass and span two wide gorges by means of suspension bridges.

The first of the suspension bridges will be over White River in Utah. This river, which incidentally supplies water for the mining and pipe line operation, has cut a wide, deep gorge, and after considering the possibility of an alternate route, it was decided that the most practical course would be to span the river with a 600-ft suspension bridge over White River Canyon.

The route of the line will then be through other exceptionally rugged country, known as Evacuation Wash, which it will cross with a 700-ft suspension bridge, then follow the Wash to its headwaters near Baxter Pass. The line will cross the pass at an elevation of 8492 ft, and from that point the right-of-way will be downhill to the refinery at Gilsonite.

Line pipe used is API 5LX 46, all 6⅝ in. OD. The 71 miles include 50 miles of pipe having a wall thickness of 0.188 in., 10 miles with 0.375-in. wall thickness, 10 miles with 0.280-in. wall thickness, and 1 mile with 0.250-in. wall thickness. The pipe is being coated with Somastic and welded throughout. Approximately 10 per cent of the welds will be spot checked with X-ray. Some of the ditch can be made with conventional ditching machines, but since a large part of the right-of-way is through rocky areas, blasting, air drills and backhoes are being used extensively.

A total of five plug type gate valves will be installed at strategic points on the system.

Pumping Station

The Gilsonite-water slurry will be pumped through the line by a three unit pump station situated at Bonanza, one of the pumps being a standby. There will be no intermediate station.

The pumps will be a 4½-in. by 18-in. duplex plunger power pumps with carbon-steel cylinders, 440-stainless-steel plungers, and spherical seated spring loaded valves. Pumps will have a 4.9:1 geared speed reduction, and will be driven by 300-hp, 440-volt, 3-phase, 60-cycle, 860-rpm motors.

As auxiliary equipment there will be two 700-hp diesel engines, one driving an air compressor and the other a jet cutting water pump used in the mining operation. The pump is rated 670-bhp at 900 rpm. The prime mover and pump are connected by speed reducing chains in a ratio of 4.67:1.

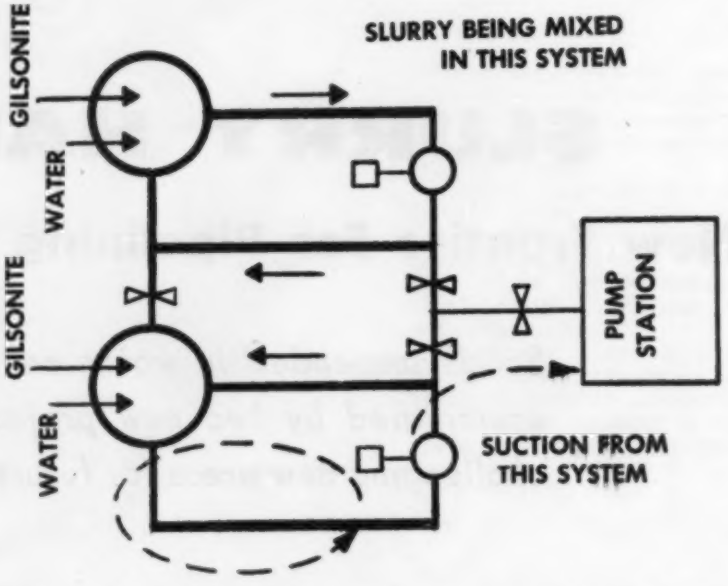
Pumping pressure of 2200 psi will be maintained on the line to provide a flow rate of 200 to 500 gal per min. This rate will deliver approximately 630 tons of Gilsonite a day to the processing plant, which will have an output of 250 tons a day of coke, 1300 bbl of gasoline, and 300 bbl of fuel oil.

How Slurry Is Mixed

At the pump station, two tanks will be used for mixing the slurry. Each tank will hold a 12-hr mixture. While the slurry is being taken from one tank, it will be mixed in the other. (See drawing) The slurry mixture is circulated constantly in both tanks to prevent sedimentation. Each of the circulating systems has a large volume, low head centrifugal pump driven by an electric motor to mix the slurry. The two systems are interconnected with a gate valve installed on the connecting line.

Concentration of the slurry will range from 80 per cent water — 20 per cent gilsonite to 40 per cent water — 60 per cent gilsonite.

There are practically no precedents for this type of pipe line, and questions that arose in the minds of design engineers had to be worked out by means of research. A pilot model was built at the Colorado School of Mines Research Foundation, Inc., Golden, Colorado, where many of the answers were obtained. One phase of this work was to measure the radioactivity of the slurry in the effluent to determine as nearly as possible the corrosion and abrasiveness that would take place on



The Gilsonite-water slurry will be mixed in two tanks, each holding a 12-hr mixture. While slurry is being taken from one tank, it will be mixed in the other.

(Photo courtesy The Standard Oiler)

Paul Borden, foreman of the Gilsonite pilot plant at Bonanza, with a pile of ore (left), which will be processed into coke (center) and gasoline (right).

the interior of the pipe. The test was made by including a radioactive section of pipe in the test line. As a result, it was found that, by removing free oxygen from the slurry with sodium sulfite, corrosion could be virtually eliminated.

Another matter of great importance was whether the solid material would settle out of the slurry as it passed through the line. The solution here was to keep the slurry moving through the line at relative high velocity, and equipment will be installed to accomplish this objective.

Taken into consideration, also, was the possibility that pumping might shut down for one reason or another. Would the solid material slide to low places and plug the line? The line is being laid with a slight downhill grade to eliminate the possibility of plugging, but also, the diesel-engine-driven pump that supplies water for jet mining will automatically switch to the pipe line and fill it with water to displace the slurry, leaving the line clean and full of water until the slurry pumps are put into service again. Should the jet cutting water also fail, water will be introduced into the line from a reservoir being constructed at the top of Baxter Pass, the highest point on the line. This water will flush the line in either or both directions, as necessary. Experiments have shown that, because of the slope of the line, there is little likelihood slurry would remain in the line in case of an emergency shutdown, but if it did, in all probability it would cause no trouble. Nevertheless the line will be flushed as a matter of precaution.

The station building is of closed type, with steel frame and steel siding. The foundation is concrete. The building is heated by using the exhaust heat from the diesel engines that drive the jet cutting water pump and the air compressor.

Line pipe all comes from west of the Rockies — Kaiser Steel and Geneva Steel. Contractor for laying the line is Engineers Limited, San Francisco.

"Wet" Mining Operation

Gilsonite occurs in nearly vertical fissures that vary in depth from 100 to 1500 ft and in width from a few inches up to 22 ft. In this instance, for the manufacture of coke and gasoline, ore will be extracted from veins that exceed 6 ft in width.

Vertical shafts are being sunk between the rock walls that enclose the Gilsonite fissure, and drifts will be cut in both directions between the shafts. The drifts will be cut in two ways, depending on the nature of the ore in the vein: (1) By jets of water under pressure of about 2000 psi, and (2) by a toothed rotary hydro-mechanical drill. Broken ore will be washed to the shaft through a V-notch cut in the floor of the drift.

At the bottom of the shaft, the water and Gilsonite that is under ¾ in. in size will be separated from the large pieces of ore. These large chunks of ore will be lifted to the surface in buckets, whereas the slurry containing the finer material will be pumped to the surface.

Processing Plant

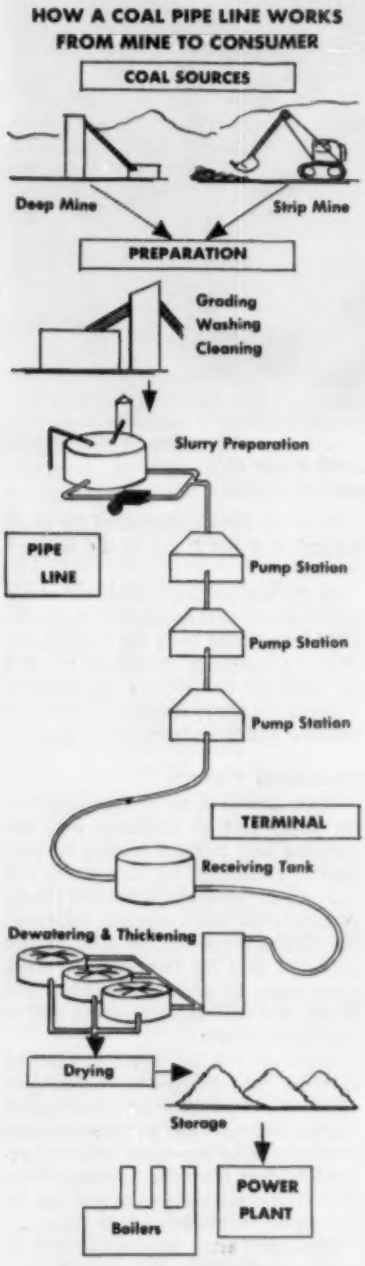
Upon arrival at the processing plant, the slurry will be subjected to a dewatering and melting process to produce a liquid feed for subsequent operations. By means of a delayed coker, a fractionator, and a catalytic reformer, the plant will convert the solid, brittle Gilsonite into 50 (weight) per cent green coke, 35 per cent gasoline, and 15 per cent 1400 Btu gas, which will be used as plant fuel.

Dried ore will be melted and heated to 450F, then charged to the delayed coker. Overhead from the coker will be fractionated and the gasoline fraction processed in a two-stage catalytic reformer. Heat from the bottoms of the fractionator will be used to melt the incoming ore before it is sent to the coker.

Gasoline, after reforming, will be finished and blended for marketing. The coke will be calcined and shipped in covered hopper bottom cars. ★ ★ ★

Coal Commutes from Cadiz to Cleveland

Dean Hale
Technical Editor



IN the rolling country of eastern Ohio, a 108-mile, 10-in. pipe line has been snaking its way across the countryside in the past year. Following an almost direct route north from Hanna Coal Company's mining operations near Cadiz, the new line will terminate at a generating plant of Cleveland Electric Illuminating Company near Eastlake, on the outskirts of Cleveland.

In appearance, this new pipe line looks much like any other 10-in. pipe line built in recent years. It is different, however, in that it will be the first major, long distance line designed and built exclusively for the transportation of crushed coal in slurry form.

To the observer watching the construction of the line, several other features are unique, too. The line has been a tough one to build, because of hydraulic gradient requirements. And the pipe used is different, consisting of heavy wall pipe that was designed into the line not because of pressures, but because of internal wear caused by movement of the coal-water slurry.

Overall, the new line presents many departures from the standard practices observed by oil and gas pipe lines, while retaining most of their features.

The most extreme departure is undoubtedly the most important. This is the realization in fact of the idea that a solid can be moved efficiently and economically through a pipe line.

The transportation of solids suspended in water through pipe is not a new idea. Man has been using the basic idea for centuries, and in modern times the idea is exemplified in hydraulic dredging. Soil movement of this type leads the field of hydraulic transport. Many of today's large earth-fill dams and the dredging of canals for marine transport service have made good use of the known techniques, as witnessed by the 100,000,000 cu yd of hydraulic fill used to build the Fort Peck Dam on the Missouri River. Some mining operations use these techniques, too, as in the case of the Copper Cliffe plant in Northern Ontario, where 4,000,000 tons of nickel ore per year are pumped.

Transporting coal by pipe line, using hydraulic techniques, has long been studied in the U. S. Early applications included a ship-to-shore installation in New York City. Several short lines have been tried by various companies. But no large scale venture had been attempted.

In Britain, experimental work has been conducted for some time. A 2000-ft line was operated at a power generation station from 1913 to 1924 and then discontinued. In France, a five mile line has been used to transport a washed slurry from mine to power station for nearly nine years.

Data on the movement of coal hydraulically, however, has been practically nonexistent. Data on solids that are either heavier or lighter than coal are available, but not analogous because of the variation in the energy required to keep each material moving.

At a 1952 meeting sponsored by Britain's National Coal Board, a group of French scientists presented some relative cost figures, based on three classifications of coal particle size. The three classifications were slurries (0 to .04-in.), duffs (0 to .125-in.) and lumps (1 to 4-in.). Costs for moving these various sizes per ton mile increased at a ratio of 1:2:6.

A 1951 report on hydraulic transportation of coal published by the Bureau of Mines gave hypothetical costs on a 100-mile, 200-ton-per-hour coal pipe line as follows:

Cost — $10,000,000

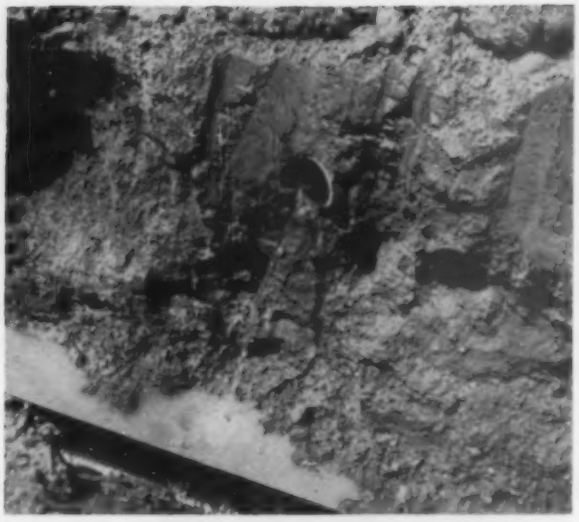
Volume of coal in suspension — 25 per cent

Water use per hour — 186,000 gal

Pump hp requirements — approximately 14,000

Operating costs for a 360-day year were computed at $1.91 per ton of coal or $0.019 per ton-mile. This included depreciation, taxes, interest, power, maintenance, supervision, and overhead. Compared to average rail transportation costs for the same period of $0.021 per ton-mile, the saving realized would be considerable. Further savings could be realized by cutting some installation and operating costs. The original plan envisioned a 12-in. slurry line and a 10-in. water return line. Eliminating the water return lowered costs considerably.

Interestingly enough, the line now being built and put into operation by Pittsburgh Consolidation Coal Company has cost relationships similar to those of the "hypothetical" line. Esti-



Special "tile replacement" crew positions a support for drainage tile. Ingenious pipeliners fabricated supports from half-sections of thin wall line pipe. Photo at right shows how backhoe cut drainage tile in making ditch. Tile is used on most Ohio farm land to carry away surplus water.

mated cost of the Cadiz-Cleveland line is approximately $10,000,000. Volume of coal suspended in the slurry will be about 50 per cent, and horsepower requirements are considerably lower.

The 108-mile, 10-in. line traces its way from the mines south of Cadiz north and slightly westward to Eastlake, which is located on the shore of Lake Erie northeast of Cleveland. The lines passes near the cities of Carrollton, Canton, Alliance, and Ravenna. The terrain generally is rolling and predominantly farmland. The latter two presented problems for the designers and builders.

Because of hydraulic gradient requirements that the grade could not exceed 19 per cent at any time, it was necessary for the contractor to make deep cuts in many locations to eliminate unnecessary sags and overbends.

Cost of securing right-of-way on high priced farm land caused headaches, too. To lower costs, the line was designed for a 30-ft right-of-way. This meant that in many cases the equipment — such as tractors, trucks, and other machines — couldn't pass on the available space next to the ditch. They could only "move up," which slowed operations.

Smaller equipment might have solved this problem, pointed out one pipeliner on the job, but with the heavy pipe being used and the ditch excavation problem, it was necessary to use standard tractors, trenchers, backhoes, and other equipment.

Frequent spring rains hampered construction, making farm land soft and difficult to work on. Pipe gang here prepares to cross a draw filled with water that remained for days. Mud combined with narrow 30-ft right of way caused many headaches.

In some areas, water filled trenches and because earth was soaked, could be removed only by constant pumping and normal evaporation. "Almost like pipelining in Louisiana's swamps," remarked one veteran pipeliner.

Heavy wall pipe was used throughout. Shown here is section of .438-in. wall pipe.

Pipe was protected by primer coat, followed by ⅜-in. coal tar enamel coat and single glass fiber wrap.

The 19 per cent grade allowed on the line resulted from extensive research that showed that this was the maximum grade at which the line could operate efficiently.

Because of the erosive-corrosive nature of the material being transported, some unusual welding problems arose. The heavy wall pipe used made it necessary to make 16 passes to complete a weld.

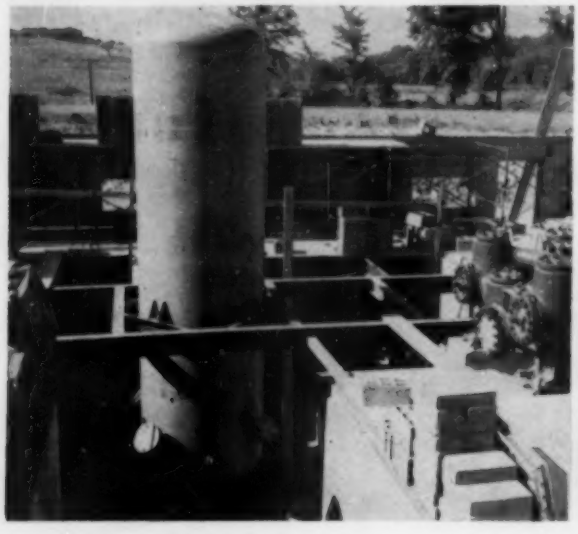
All pipe used on the line was of API 5 LX-42 specifications, a high tensile steel. Bulk of the pipe was furnished with a 30 deg bevel for welding. A relatively small amount was furnished with a 37½ deg bevel. Stringer beads were used for all passes, except the cap pass, which was a wide weave.

During cold weather, pipe was welded without preheating by not allowing the pipe to cool between passes. Filler pass welders moved in quickly behind the stringer and hot pass welders. Filler pass welders kept two joints hot at the same time by alternating their welding back and forth between the two joints.

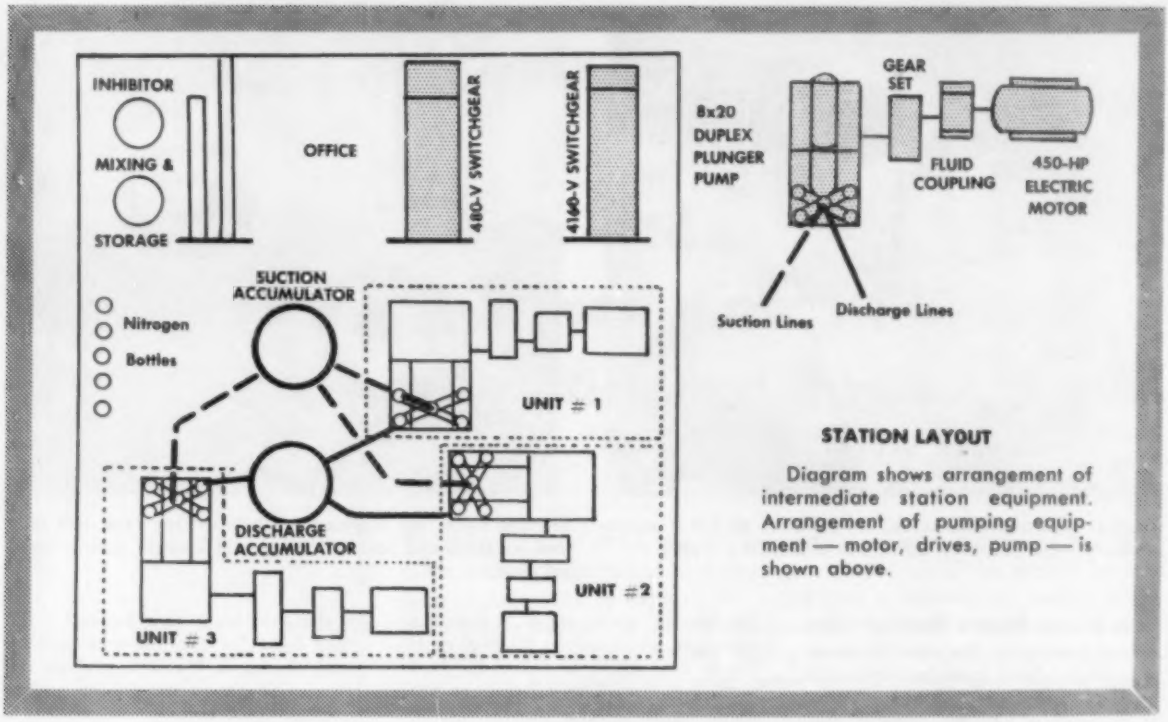
To prevent underbead cracking, it was necessary to have stringer bead welders strip three inches, top and bottom, before moving pipe to the next line-up.

Pipe used for the line varies in wall thickness from .687-in. down to .365-in. For a 10-in. line, this is heavy pipe. Pipe from the discharge side of the station is .687-in. for approximately five miles, then tapers down to .593-in. for a short distance, then to .438-in. wall for another segment, and ending on .365-in. wall for the remainder of

Large "accumulator" tank, made of 1¼-in. steel, will reduce line surges in station. Nitrogen will be used to "pack" the top of the accumulator.



View of station under construction. In foreground, under canvas wraps (for protection against weather) can be seen 450-hp motor, gear set for speed reduction, and duplex piston pumps. Fluid coupling had not arrived when photo was taken.



STATION LAYOUT

Diagram shows arrangement of intermediate station equipment. Arrangement of pumping equipment — motor, drives, pump — is shown above.

the section up to the next station. This range in sizes is then repeated for the next station-to-station section.

Why such heavy wall pipe? The original slurry mixed at the Cadiz station consists of coal particles fresh from the grading-screening operation. These particles have rough, sharp corners. Moving through the line, they tend to abrade the pipe, As their movement progresses, these corners "round off."

Thus the greatest amount of degradation of the internal pipe surface is near the beginning of the line and less at the terminal end. Velocity of the slurry is also greater at the discharge side of each station and with the high velocity, there is likely to be greater turbulence, creating greater internal surface wear.

To prevent internal corrosion, caused by free oxygen in the slurry and from contaminants in the coal such as sulfur, two types of inhibitors will be injected into the line — caustic soda and sodium chromate.

External corrosion protection consists of a primer coat, followed by a coal tar enamel application over which is wrapped a single layer of glass fiber.

A problem typical of any pipe line construction in this area also cropped up in this job — drainage tile cut by trenching machines digging across the farm land. The contractor had special crews on the job replacing the tile after the pipe was lowered-in.

Pumping Stations

Three stations will provide the pumping power for the line. Initial station is located near Cadiz, where the slurry is introduced into the line. A second station, near Carrollton, and a third station, north of Alliance, will provide additional boost to the flowing slurry. Station spacing is approximately 30 miles between stations 1 and 2 and between stations 2 and 3. From station 3, the distance is 50 miles to the line's terminus, which follows a "downhill" slope.

Each of the stations will be semi-automatic in operation, with one man in attendance. All are electric powered, and all power is purchased.

Each station will have three pumping units. These consist of a 450-hp, 480-v, 3Φ, 60 cycle, 1800-rpm, electric motor driving the pumps through a 6.742:1 gear reduction set. Connected to this is a fluid coupling, which does two things — provides even torque to the pumps and compensates for liner wear in the pumps.

The pumps are 8 by 20-in. duplex plunger power pumps, adapted from standard petroleum industry pumps of this type. Special features of the pumps include special valve rubbers, special piston inserts, and special liners.

Suction pressure at the intermediate stations will be in the range of 300 to 400 psi. Discharge pressure of the pumps, using 8-in. liners, is a maximum of 880 psi. Normal operation will be in the range of 350 psi suction and 800 psi discharge. Discharge pressures up to 1200 psi can be obtained by using different liners.

On the suction side of the intermediate stations, the slurry is received into an "accumulator," a tall cylindrical pressure vessel, which is packed with an inert gas (nitrogen) at the top. The discharge side of the pumps goes into another accumulator, and then into the line. The accumulators are provided to protect the station piping and line pipe from destructive surge forces.

Another unique feature of the stations is the water flushing system. If shutdown of the station is necessary, all lines, pumps, tanks, and other slurry handling equipment are washed clean by a flow of clear water. This system comes into operation in event of any shutdown.

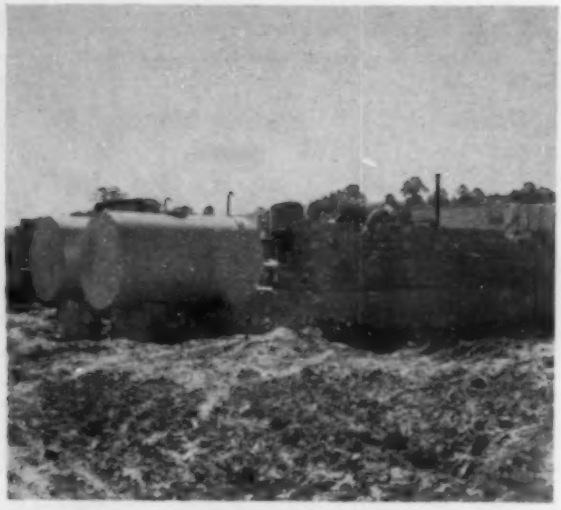
The entire system will be flushed clean — stations and line — once each year as a routine maintenance procedure.

Each of the intermediate stations is also provided with a large standby slurry pond that has a capacity twice that of the preceding section of line. In event of line failure or other emergency, the slurry will be allowed to flow in these ponds, where it will dry by evaporation and the coal can then be trucked away.

A complex manifolding system ties-in the station's suction, intermediate and discharge lines to the flushing system through use of three-way valves.

Continuous specific gravity readings are taken of the slurry steam by a new differential pressure reading device.

Another view of station under construction. At left is accumulator, at rear is control panel still in shipping crates.



Storage tanks for chemical inhibitors. One tank will hold sodium chromate solution, other will contain caustic soda solution.

How Slurry Moves Through Line

In a strict sense, the pipe line movement of the slurry from the mine to the final dry coal pile is nothing more than an extension of a normal phase of mining operations employing hydraulic movement of coal.

Coal, after being separated from its formations in the earth, must be graded and cleaned and moved to storage for further transportation to the ultimate user. The pipe line merely replaces the short lines of the mine and totally replaces (in this particular case) the rail transportation of coal from mine to power generating station.

At the mine, the coal is graded into sizes. These start with a plus 5-in. size (which may be crushed to fines if not sold), then through a range as follows: 5 by 2-in., 2 by 1½-in., 1½ by ⅜-in., ⅜-in. and smaller.

The latter size is used in the slurry. After being graded, these ⅜-in. and smaller coal fines are cleaned, crushed, and made into a slurry at the mine.

At the slurry preparation plant, a mixture of 50 per cent coal fines and 50 per cent water is prepared. The mixture is kept in circulation, and suction for the initial station is taken from this constantly circulating stream.

From the initial station, and through the two intermediate stations and the length of the pipe line, the mixture is handled in a manner similar to that of any other liquid pipe line.

Arriving at the terminal, the slurry mixture is discharged into tanks and kept circulating, to prevent sedimentation. Next step in the process is dewatering.

The slurry is then moved into flocculating tanks, where the process of "thickening" takes place. A flocculating agent, which causes the coal particles to coalesce, is added to the coal-water mixture. The mixture is constantly agitated and as the mixture thickens, free water flows off.

From the thickeners, the coal, which now has very little water in it, is dried further and then stockpiled for use in the boilers of the power plant.

Economics Behind The Line

Moving at a rate of approximately 3½-miles per hour through the pipe line, the slurry stream will deliver about 1,300,000 tons of coal annually from the mine to the power plant.

Average daily movement through the line will be about 3600 tons — the equivalent of 48 railroad cars of 75-ton capacity.

How much will this mean in savings in transportation costs? Present rail tariff from Cadiz to Cleveland is $3.25 per ton, for coal delivered from the mine to an unloading point.

Conservative estimates are that the slurry pipe line will be able to deliver coal to the power station site for approximately $2.00 per ton — or less. It is easy to see that such a savings would greatly appeal to both the mining company and to the user.

More than five years of research by Pittsburgh Consolidation Coal Company went into the project before the decision was reached that a pipe line would be feasible.

A 17,000 ft pilot line has been in operation for some time at the company's Library, Pennsylvania, facilities.

As a result of these studies, a consulting engineering firm, Ford, Bacon & Davis, was called in to make a feasibility study, which in turn resulted in the green light for the 108-mile project. Ford, Bacon & Davis was given the contract to design the facility and to supervise construction.

Williams Brothers, Tulsa, Oklahoma, is contractor for the construction of the line, and Poling & Bacon Construction Company, Toledo, Ohio, is contractor for station construction.

The mine to powerhouse project may herald the coming of similar ventures. And there is good reason for this thinking, too.

Transportation of coal from mine to user has been almost exclusively performed by the railroads. And rail rates are high — averaging about 40 per cent of the cost of a ton of delivered coal. Coal, in competition with other forms of energy such as gas, oil, and electricity, has been suffering. Coal men have cut costs, cut prices, and done everything possible — only to see transportation rates rise steadily.

If transportation of coal by pipe line proves as economically feasible as is hoped, it may bring new life to the coal industry and provide impetus to the growth of the pipe line business — especially the manufacturing end of the pipe line industry which provides pipe, pumps, and construction equipment.

The railroads are also interested.

Three railroad companies have options to buy an interest in the coal pipe line after it has operated for a period of time. Several other companies have indicated an interest in the operation. Thus successful operation of this initial pipe line venture may see the railroads getting into the coal pipe line business themselves. Many own coal mining operations, directly or through subsidiary companies. ★ ★ ★

Vapor-Phase Cooling

Part 3

Stanolind's experiences show VPC to be economical, efficient, simple

EVER SINCE MAN INVENTED the internal combustion engine, he has been faced with the economical and mechanical problems of the unused heat in such engines. Now, a method—by which heat is removed by boiling water in the engine jackets—is being used successfully on many installations. Known as vapor-phase cooling or latent cooling or ebullition cooling, it costs less to install, uses less power and gives better engine performance than conventional jacket-water cooling. In addition, it effects substantial savings in fuel, water and equipment if the steam can be utilized. For these reasons, everyone who designs or uses internal combustion engines should be interested in further use and development of vapor-phase cooling.

G. O. Bates, *Mechanical Engineering Supervisor*

J. E. English, *Senior Mechanical Engineer*

G. M. Franklin, *Senior Mechanical Engineer*

Stanolind Oil & Gas Company, Tulsa, Oklahoma

VAPOR-PHASE cooling systems were first used on single cylinder engines fitted with open tanks filled with water in which the power cylinders were immersed. Cooling occurred as water boiled from the hot surfaces within the jacketing vessels. The forerunner of today's system appeared on such engines as early as 1920, when they were fitted with closed hoppers and steam-condensing air-cooled radiators to prevent loss of cooling water. Modern horizontal engines using such cooling systems were developed for oil field pumping service during the 1940's.

As far as is known, there was no directed attempt to elevate the temperature of the cooling water to the range of 212 F to 250 F in jacket systems for vertical multicylinder industrial engines until the late 1930's. About that time, a high temperature cooling system was introduced which claimed to reduce cylinder wear, to permit use of sulfur bearing fuel gas and to increase thermal efficiency through recovery of waste heat. That system differed from a vapor-phase system in that a pump was provided to force circulation through the jackets in order to suppress free boiling within the engine.

From 1939 to 1952, this system won a gradually increasing acceptance, usually being favorably considered only when the ability to burn sulfur bearing fuel or the recovery of waste heat was significantly advantageous. The effort to attain recognition for the system as a cooling method for engines was resisted by most engine users and builders, who were uncertain as to what troubles might arise from high temperature cooling and were satisfied with cooling from conventional closed water systems operating in the medium temperature range.

In 1952, O. B. Freeman of the Tidewater Associated Oil Company, Ventura, California, experimented on vertical multicylinder gas engines with high temperature cooling without the jacket-water pumps. In his experiments, boiling was permitted within the jackets to promote natural circulation through the engine. Apparently, the additional economy permitted by the omission of the water-circulating pump created general interest in this type high-temperature cooling among operators of oil field gas engines. As a result, over 40,000 engine horsepower in compressor service alone has been

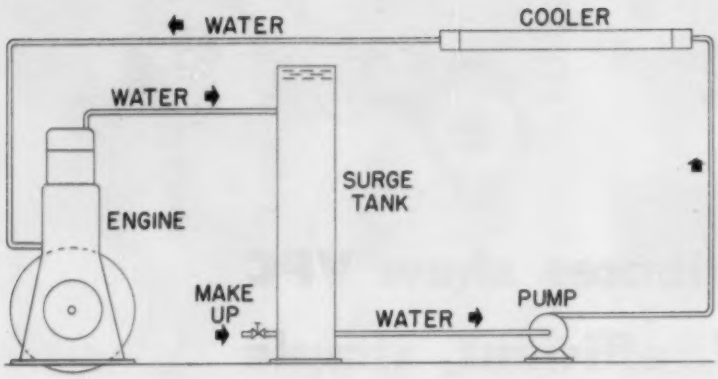


FIG. 1. Diagram of conventional cooling system.

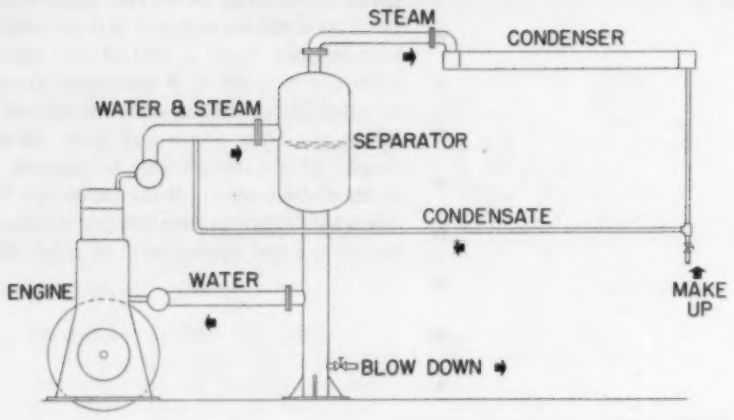


FIG. 2. Diagram of vapor-phase cooling system.

equipped with vapor-phase cooling since 1953.

Comparison of Systems

Fig. 1 shows a conventional forced-circulation water system with the engine, the surge tank, the pump and the cooler.

Fig. 2 shows a simplified vapor-phase cooling system with the engine, the separator and the steam condenser. A mixture of water and steam from the engine enters the separator. The steam flows to an elevated condenser from which condensate is returned by gravity to the fluid stream entering the separator. This mixing ahead of the separator provides uniform temperatures in case the condensate has been subcooled. There are no pumps because all circulation is maintained by the difference in densities between the water in the separator and the mixture of water and steam in the jackets.

The vapor-phase system requires less heat transfer surface and a smaller cooling-air fan than a comparable forced-circulation water system because of the greater temperature differences and higher heat transfer rates that result when condensing steam.

Power requirements are less because of the smaller fan and driver and the elimination of the engine-jacket water pump. Obviously, operating and maintenance costs are lower for the same reasons.

In addition, engine maintenance costs are reported by several operators to be less. Uniform heat transfer at a high rate is achieved by the turbulent boiling action and there is little or no gradient in the temperature of the coolant. Therefore, the cylinder walls have more uniform temperatures and less distortion or taper than with conventional cooling. Those conditions result in less wear of the cylinders and pistons, thereby reducing pistol blowby and oil sludging.

Fig. 3 compares the initial costs of cooling equipment for both vapor-phase systems and conventional systems for slow-speed engines. Cost in dollars per engine horsepower based on June, 1955 prices is plotted against engine horsepower. The costs for vapor-phase systems include the purchase prices for a separator, an air-cooled steam condenser and the necessary instruments and controls to maintain a steam pressure less than 5 psi. The costs for conventional systems include the purchase prices for a jacket-water surge tank, a jacket-water pump, an air-cooled exchanger and the necessary instruments and controls to maintain a maximum water temperature of 170 F.

Fig. 4 compares the auxiliary power required by cooling equipment covered by Fig. 3 for both systems for slow-speed engines. Auxiliary horsepower, expressed in per cent of engine horsepower, is plotted against engine horsepower. The power for the vapor-phase system is that required by the fan. The power for the conventional system includes that required by the fan and the jacket-water pump.

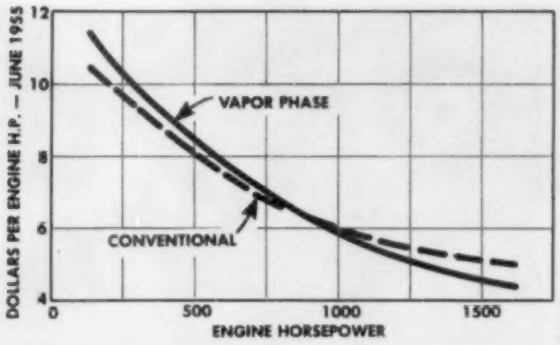


FIG. 3. Comparison of initial costs of cooling equipment for vapor-phase and conventional system for slow-speed engines.

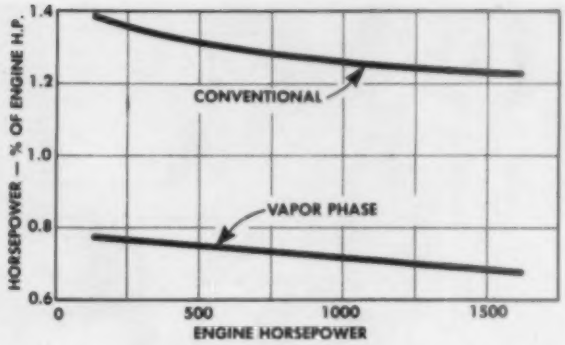


FIG. 4. Comparison of auxiliary power required by the vapor-phase and conventional systems for slow-speed engines.

Fig. 5 compares the installed costs of slow-speed engine cooling equipment for both systems. The units and the basis for the indicated values are similar to those of Fig. 3. The costs include all labor and material required to make the installation ready for operation.

Fig. 6 compares the initial costs for cooling equipment for both systems for high-speed engines. The units and the basis for the indicated values are similar to those of Fig. 3.

Fig. 7 compares the auxiliary power required by cooling equipment for both systems for high-speed engines. The units and the basis for the indicated values are similar to those of Fig. 4.

The costs and auxiliary power requirements for the factory-equipped conventional system (radiators) furnished with high-speed engines are based on data obtained from a limited number of engine manufacturers. Power requirements and costs for engines furnished by other manufacturers may vary slightly from the data indicated. However, these values are considered sufficiently accurate to be satisfactory for this comparison.

In all cases, the data apply to complete systems for cooling only jacket-water on single engines. For cases where a single system is used for cooling several engines or jacket cooling is integrated with other services, somewhat different data will apply.

Installed costs for cooling equipment on high-speed engines are not given because such data were not available.

No data are given for high temperature water cooling systems because there are no economic or operational advantages for such systems in comparison with vapor-phase systems.

At least 15 per cent, and in many cases as much as 30 per cent, of the heating value of the engine fuel goes into steam, which is generated in a vapor-phase system. Therefore, very appreciable fuel savings can be made if the steam can be utilized, although it is normally condensed in an air-cooled unit.

If the steam is used, a condensate return system is usually required, but

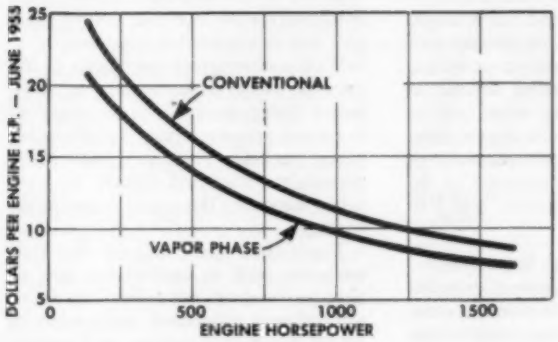


FIG. 5. Installed costs of cooling equipment for slow-speed engines.

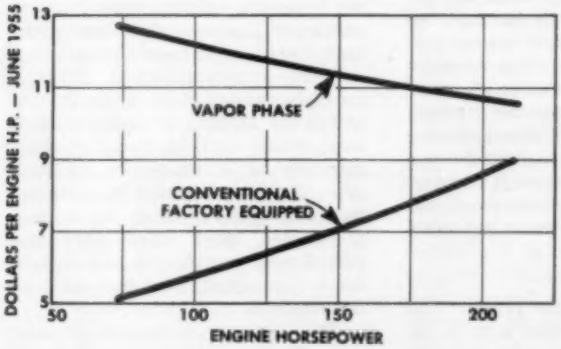


FIG. 6. Initial cost of cooling equipment for high-speed engines.

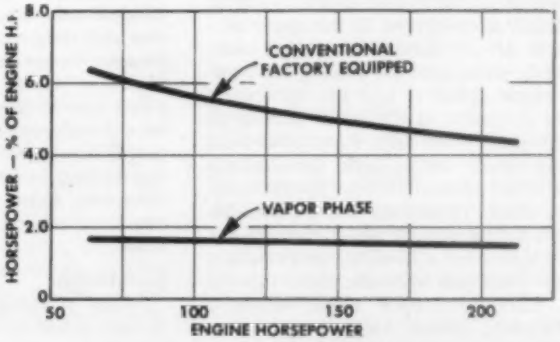


FIG. 7. Auxiliary power required for high-speed engines.

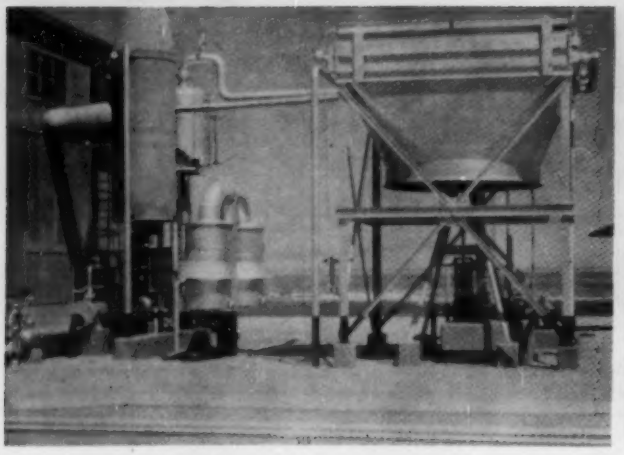


FIG. 8. Exterior of plant showing steam condenser, right, separator, air intake filters, and muffler.

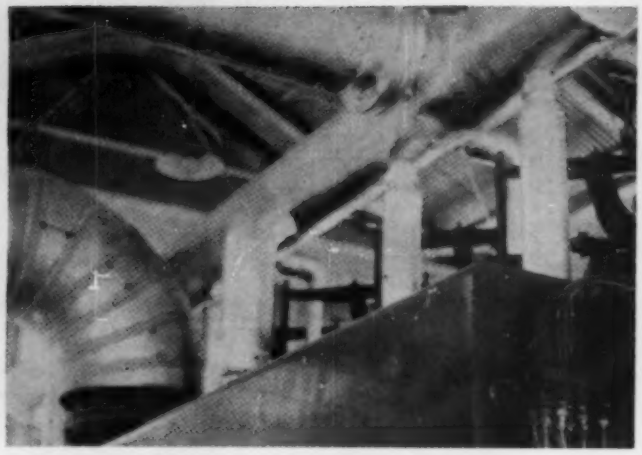


FIG. 9. Overhead lines that carry steam to the condenser and water for cooling compressor cylinders and lube oil.

that cost is offset to some extent by a reduction in size of the steam condenser. In addition, boiler feedwater and steam generating facilities can be reduced. Usually, a small excess steam condenser is required to handle variations between the rates of steam generation and demand.

At present, steam pressures above 25 psig are not feasible in standard engine jackets. Such low pressure steam can be used for space heating, process heating and absorption-refrigeration. If higher pressures could be generated, more general use of the steam could be made, with attendant savings in boiler facilities. High temperatures associated with the higher steam pressures would probably have some effect upon cooling efficiency. However, potential savings are so great that considerable experimental and development work on high pressure jackets is justifiable.

Description of Stanolind's Installations

Each of four engine driven compressors at the Midland Farms plant is equipped with a vapor-phase cooling system similar to that shown in Fig. 2. Steam is condensed in the upper section of an elevated air-cooled unit, while water used for cooling the compressor cylinders and the lubricating oil is cooled in the lower section of the unit. Each unit is equipped with two small forced-draft fans, which blow air vertically across the two coils in series. Those fans and a pump for circulating cooling water through the compressor cylinder jackets are equipped with hydraulic motor drivers.

Each compressor engine drives a hydraulic pump which supplies hydraulic power to the motors. Originally, a manual by-pass around each hydraulic motor provided speed control for varying the flow of air and water. The fans are now equipped with automatically controlled by-passes actuated by steam pressure. Controlling the fan speed in this manner prevents fluctuation of the steam pressure with changes in atmospheric temperature.

One engine-driven compressor at South Fullerton plant is equipped with a vapor-phase cooling system. This installation is illustrated by Fig. 8 through 11. The system is similar to those at the Midland Farms plant except that the cooling unit has a single fan which is driven by an electric motor. Since the fan speed is constant, an automatically operated shutter is provided on top of the steam coil to prevent fluctuation of the steam pressure with changes in atmospheric temperature. The shutter is actuated by the steam pressure and maintains it at 2 to 3 psig.

Results of Operating Experience

A single system to serve all engines was considered for Midland Farms but since that was a trial installation, individual systems were used in order to simplify operations and to provide maximum performance data. The individual units are usually more expensive and they necessitate special precautions to prevent freezing when an engine is not in operation. A combined system minimizes the freezing hazard because some thermal circulation is maintained throughout the system as long as one engine is running. Therefore, future installations will use combined cooling systems where practical.

Circulation

When a vapor-phase system with thermo-siphon circulation is to be installed, it is essential that the pressure drop through the equipment and piping be thoroughly investigated. The relative elevation of the separator and engine and of the condenser and separator are controlled by the pressure drops in the system.

Restrictions in the piping to and from the engine reduce the amount of water circulated through the engine and restrictions in the steam piping to the condenser raise the operating pressure of the system. An inadequately sized condensate line restricts flow from the condenser, thereby flooding some of the condenser surface. This condition results in higher system pressure and in sub-cooled condensate.

With some engines alterations of the internal jacket construction or additional piping connections are required to reduce pressure drop or to eliminate vapor pockets. Therefore, the engine manufacturer should always be consulted regarding the use of vapor-phase cooling.

Experience has indicated that it is advisable both to control the flow of air and to slope the tubes for drainage in any air-cooled equipment in which the fluid is subject to freezing. Under certain conditions where the condensate became sub-cooled and did not flow with sufficient velocity, some sections of air-cooled steam condensers have frozen while in operation.

When a constant-speed driver is used, the amount of air is usually controlled by shutters or variable pitch fans, which may be operated either manually or automatically. In some cases, the flow of air may be controlled by changing the speed of the fan with a variable speed drive. Otherwise, complicated instruments and controls for a vapor-phase cooling system are not required.

The separator is usually provided with a low-level alarm or shutdown device, a gage glass and a pressure relief valve. The condenser is provided

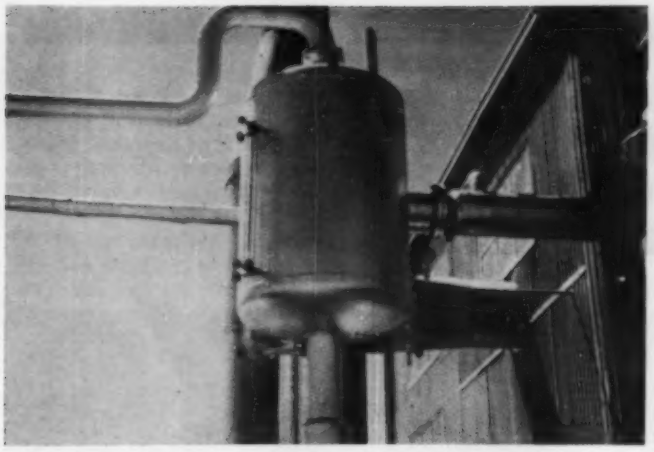


FIG. 10. The separator is provided with a low-level alarm or shutdown device, a gage glass, and a pressure relief valve.

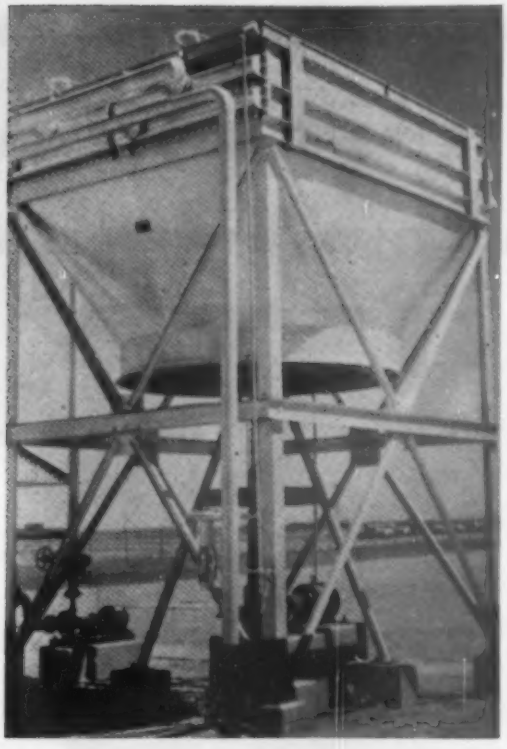


FIG. 11. Steam is condensed in the upper section of an elevated air-cooled unit; water for cooling cylinders and lube oil is cooled in the lower section.

with a combination vent and vacuum breaker which removes noncondensables and prevents vacuum in the system when it cools after shutdown.

Some difficulties were experienced in operating the hydraulic drive systems on the Midland Farms units due to faulty hydraulic equipment and foreign material in the hydraulic lines. However, replacement of the faulty equipment and modification of the system have appreciable improved operation. Operators report no particular difference in operation from conventionally cooled engines, except for the freezing problem which was discussed earlier.

No detonation difficulty has been reported although the fuel has a rather high Btu content. The oil has not been adversely affected to any detectable degree by vapor-phase cooling. No extraordinary sludging is indicated in the full flow oil filters.

Performance

Engine performance tests demonstrated that the South Fullerton engine could handle 120-125 per cent of its altitude horsepower rating after six months' operation. Such performance is obtainable only if the engine is in good mechanical condition and therefore it indicates that no unusual wear has occurred. No inspection has been made of the condition of crankcase, bearings, or power cylinders, but there is no indication of piston blowby or sludging of the oil. There has been no detonation experienced except for a slight pinging when the engine was overloaded. Operators report that the engine cooled by vapor-phase required less attention and runs smoother than any of the other eight compressor engines at the location. There are no particular startup, shutdown, or operating problems.

Water Treatment

Proper water treatment is essential for low maintenance and continuous operation in any system which uses water. Normally, treatment for steam systems is more expensive and requires closer attention than treatment for liquid systems. However, treatment of vapor-phase systems for engine cooling is not difficult because of low make-up requirements with the closed cycle.

If possible, steam condensate or rain water should be used in any type of jacket-water cooling system. With such water, satisfactory protection against corrosion can be obtained with the same high chromate treatment that is suitable for conventional systems. If raw water must be used, a phosphate treatment suitable for low pressure boilers will protect against formation of scale. With such treatment, a sulfite residual must be maintained in the system at all times to prevent oxygen attack.

Conclusions

On the basis that vapor-phase cooling is economical, efficient, and simple, as indicated by the cost and operating information presented here, the authors' company expects to make general use of such cooling on future installations of slow-speed gas engines, except for unattended units in areas with serious freezing problems.

Several companies already have similar plans and others may be expected to follow the trend to make vapor-phase the generally accepted method for cooling internal combustion engines. Therefore, manufacturers should be ready to provide engines that are satisfactory for vapor-phase cooling without alteration of the jackets or installation of complicated piping. Jackets also should be designed for high pressures so that steam generated in them can be used for general service. Then the internal combustion engine will be more efficient than was ever hoped in the past.

Acknowledgments

The authors thank the management of Stanolind Oil and Gas Company for permission to publish this article. Appreciation is also expressed to operating personnel who provided information from the plants and to G. C. Hickman who assisted in preparation of the cost data.

This discussion was originally presented at the ASME Petroleum Mechanical Conference, New Orleans, Louisiana, 1955. ★ ★ ★

IDEAS AT WORK

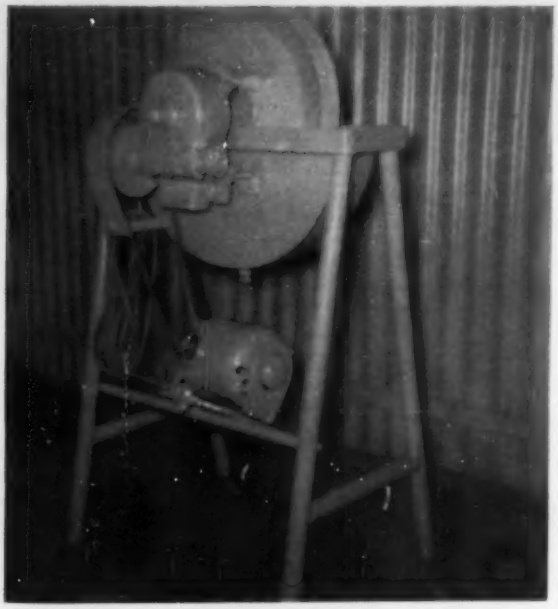
IN PIPELINING

Your Ideas Are Worth Money

If you have an operating idea or have devised a piece of equipment to do a job easier or cheaper, send it to us with a photo or drawing (we fix up rough sketches) . . . we will pay $10 for each idea used.

Shop Utility Table

This shop utility table was made from ¼-in. pipe braced with same and a small angle iron. Casters were salvaged from an automobile "creeper" and inserted in ends of legs. The top was made from ¼-in. plate welded with a ¼-in. pipe lip extending around all four sides to keep small parts from rolling off. Good for maintenance shops, etc.



Make a Grindstone from an Old Washing Machine

Grandpappy used 'em and no one's come along with anything much better than an old fashioned, slow-speed grindstone for sharpening tools. It is wetted and cool and this helps preserve the temper of the steel cutting edges. Besides, its slow speed reduces the hazard.

Here is one that a compressor station maintenance crew made of scrap steel and pipe and an old Maytag washing machine that had been tossed in the junk heap. The only thing store bought about it is the grindstone itself and it is the double disk kind with one side for sharpening and one for smoothing.

The electric motor and reduction gear came from the clothes washer. The stand was made mostly from 1¼-in. pipe and the tank beneath the grindstone was fabricated from ⅛-in. steel plate.

Steps on the Back of a Truck for Safety's Sake

One of the major sources of minor injuries to crewmen is getting on and off trucks. One company overcame this by welding steps similar to those attached to railroad freight cars on the back of a truck. The two steps as shown here are made from one-inch pipe and the two vertical hand rails are made from one and one-half inch pipe, orange peeled at the end to prevent injury. These "rails" can be removed if necessary.

The "SKY HOOK" a Reality

The "sky hook" is a safety device consisting of two hinged L-shaped bars which form a clamp that encloses the flanged rims of floating-roof tank shells. These L-bars, made of iron or steel, are locked in position by a pin that passes through aligned holes drilled in the horizontal arms of the bars themselves. The workman's safety line is connected to any eye on the bottom of this pin.

The unit slides along the flange as the workman moves. This eliminates the protection lapse that occurs with detaching and re-attaching each time the workman moves to another position as is required with C-clamps.

Referring to the drawings and particularly to Fig. 1 and 2, reference numeral 10 designates an elongated first bar, usually of iron or steel, which is pivotally connected at one end of a second bar 11 by means such as a hinge 12, through which is a pin 13. Bar 10 is bent at right angles at point 14 to enclose the angle between the vertical inner face of tank shell 15 and the horizontal top face of the angle member 16 at the top rim of the tank. Similarly, the second bar 11 is bent at 17 to lie below the top leg of angle member 16 and outside of the tank shell, as shown best in Fig. 1.

To retain the clamp thus formed in locked position on the tank rim, bars 10 and 11 are provided, in this example, with welded bosses 18 and 19, which are drilled as at 20 and 21 to form aligned apertures for a pin generally designated 22 to pass through both bars when they are in closed position. Head 23 on pin 22 serves to prevent it from dropping entirely through apertures 20 and 21. An opening 24 adjacent the free end of the pin 22 is adapted to receive the hook portion 25 of a conventional spring connector 26 of a safety belt (not shown) to which it is joined by a strap 27.

Desirably but not necessarily, the end of pin 22 at the opening 24 is flattened as at 28 to be wider than the shank of pin 22. To permit passage of this wider portion through apertures 20 and 21 in bosses 18 and 19, the latter are slotted as at 29 and 30. Referring to Fig. 2, it will be noted that the construction just described will serve to lock the clamp on angle member 16 and tank shell 15, in the absence of the hooked spring connector 26, by giving pin 22 a quarter turn. A loop or handle 31 or pin 22 will serve to indicate the position of pin 22, as well as to act as a convenient means for sliding the whole assembly circumferentially around the tank rim without detaching it therefrom.

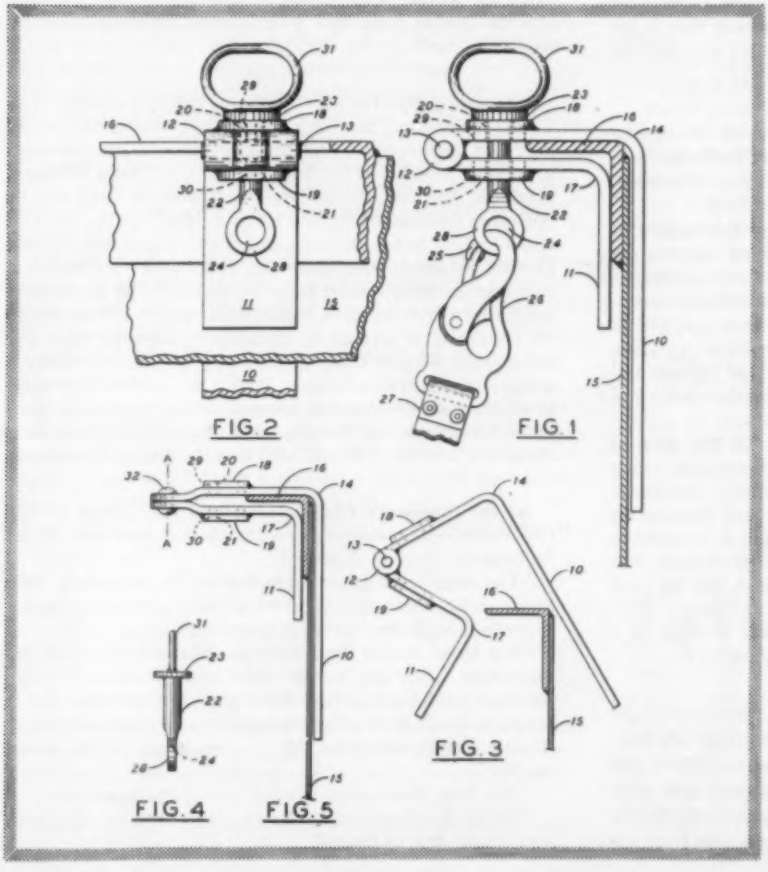
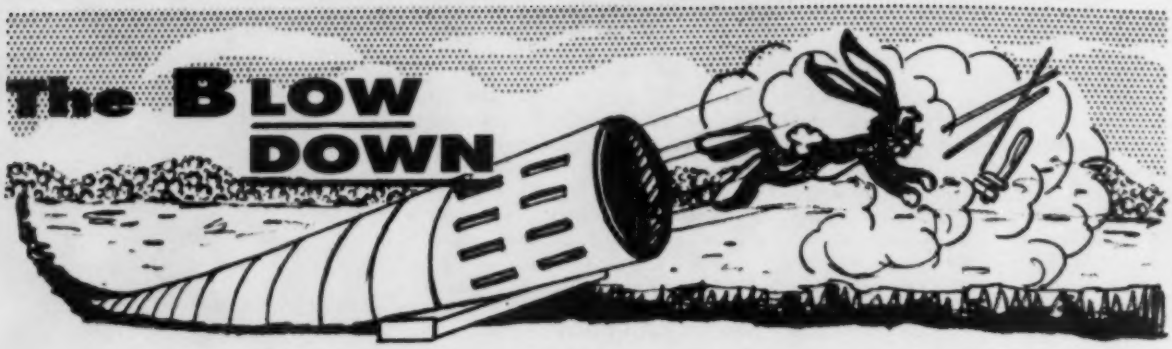


Fig. 3 illustrates how the clamp arrangement of Fig. 1 and 2 is opened, by removing pin 22, so that it may be placed over the angle 16 and shell 15 to assume the closed position, whereupon pin 22 is inserted through aligned apertures 20 and 21 to receive the hook 25 of connector 26, as described. Removal of the clamp from the rim is accomplished by first disconnecting the connector 26 and withdrawing pin 22, whereupon the pivoted bars are opened, as shown.

Alternatively to the transverse hinge 12 of the arrangement of Fig. 1, the pivoted connection between the end of bars 10 and 11 may be made as shown in Fig. 5, wherein a rivet 32 joins those members. The inner or lower bar 11 is then swung around the axis A-A of rivet 32 with respect to the upper or outer bar 10, to permit installation and removal of the clamp by a straight downward or upward motion. When the bars are in alignment, pin 22 may be inserted through the apertures 20 and 21 to lock the clamp onto the tank rim or other structure. ★ ★ ★



News from the Field and Plant about People you know

When Gulf Coast Editor Don Taylor was visiting Stanton, Kentucky, to make photos for the stories on Gulf Interstate's new automatic compressor station, he asked to meet Max Levy, Gulf Interstate's engineer of all work, who labored night and day to get the station ready for remote operation. "Just look for a guy who needs a shave and a haircut, wearing run down GI shoes and old GI pants — that's Max," he was told.

After searching fruitlessly for someone resembling a mendicant, Taylor approached three well dressed men near the compressor building. "Anybody seen Max Levy?" he asked.

"Nope. Hasn't been out today," two of the men choroused.

"The hell he hasn't!" shouted the third man. "I'm Max Levy!" Turns out the men were so used to seeing Max in his work day habiliment that they even forgot they were talking to him when he was dressed up.

At SP's El Paso Station recently it was a real pleasure to meet **Joe Brock,** chief engineer, and **Palmer Ledbetter,** station engineer. Sorry that **Jack Davis,** district superintendent, was busy in Tucson that day and we missed him.

El Paso station, on this new products pipe line system of Southern Pacific Pipe Line, now has a rated capacity of 14,000 bbl a day, which will be increased to about 25,000 bbl in late 1957 as a result of Standard's announced plan to enlarge its refinery in El Paso that supplies SP with a part of its products. Capacity of the line will be increased by replacing present equipment with larger pumping units at El Paso and constructing an intermediate station between that point and Tucson.

El Paso station presently is pumping all the way to Phoenix, a distance of some 400 miles. This seems like a long distance for one station to pump, but, actually, instead of needing booster help it is necessary to hold back pressure on the line. This is the explanation: The stream is pumped to the top of Apache Pass, in excess of 5000 ft altitude, and from there gravitates to Phoenix via Tucson. A 600 psi back pressure is held on the line at Tucson and at Phoenix 1000 psi. The increased capacity planned would necessitate a booster station to get the fluid to the top of Apache Pass.

At American Oil Pipe Line's division headquarters at Snyder, Texas, they were talking about the merger with Service Pipe Line, a still unexplained celestial condition that caused television programs to become jumbled and even affected the company's microwave system, and the successful remote operation of Sterling City and Irion stations from the Colorado City station. **V. T. Tracy,** division superintendent, **Hayne Nelms,** chief station engineer, **C. F. Jeffress,** division electrical and communications foreman, and **John Stanley,** division clerk, were on hand. Jeffress had recently returned from his vacation in California. Tracy was contemplating waiting until fall for his.

Pipe line companies go to a great deal of trouble to keep employees (and their wives) happy. A good example of this is El Paso Natural's traveling clothing store. Many of the company's stations are far removed from stores of any kind, and the company found that the wives sighed longingly for the crush of the bargain basement. El Paso's solution was to authorize a clothing store operator to make regular calls along the system — displaying a truck load of his latest fashions on special racks in the station offices. Everything's at wholesale, too!

Internationalists for Sure. Williams Brothers Company of Tulsa, Oklahoma, has long been active internationally in pipe line construction, and deserved recognition continues to be given officials of the firm. Not long ago **John Williams,** president, was awarded the Order of Condor by the Republic of Bolivia for outstanding service to the Bolivian nation. This is the highest honor Bolivia can bestow. Latest news is that **Charles Williams,** vice president, and **C. M. Collins,** chief engineer, recently toured Iran and conferred in London on the Eastern Hemisphere's highest pipe line. Williams Brothers Company is serving in an advisory capacity with Constain-John Brown, Ltd., builders of the 337-mile southern section of the Trans-Iranian Pipe Line, which will carry products from the Abadan refinery to Teheran and is scheduled for completion this year. The line will rise from 60 ft above sea level at Ahwaz to 7000 ft in the Zedran Mountains.

At the Pipeliner's Club in Houston, Bob Lingle of Syd Culbertson was describing a recent Alaskan bear hunt where he bagged(??) an 8-ft grizzly.

"The most remarkable thing I saw," he recounted, "was an ice snake. I always thought Alaska was too cold for snakes — even though they are cold blooded animals.

"But these snakes have adapted themselves to their environment. They are almost snow white except for small flecks of black on their back; they grow to about four feet in length but their girth is seldom larger than a man's forefinger. They probably constitute the greatest danger to the novice hunter."

"Are they poisonous?" queried one of the pipeliners.

"Nope. When you stoop down, they crawl up your back and freeze you to death!"

Data from the personal notebook of the writer, previously unpublished.

EXCLUSIVE

Pipe Line Flow Calculations

J. W. J. Bercher
Consulting Engineer

THE writer from time to time has published data accumulated in a personal notebook for use in gas pipe line flow calculations and for use in design of orifice meter installations. Previously unpublished data, which are believed to be of value to those engaged in such calculations, are included in this article.

Included are functions of internal diameters of pipe sizes ranging from 2 in. nominal to 10 in. nominal. Functions of $(P_1^2 - P_2^2)^n$ as normally published would require a tremendous amount of labor to compile over the pressure ranges now common in the industry.

Since: $(P_1^2 - P_2^2)^n = (P + P)^n (P - P)^n$ a set of values of N has been prepared, where N ranges from 10 through 2000 for n = 0.5 and n = 0.5394.

A further addition is a set of values for $(1/N)^n$, where N ranges from 0.05 to 1.0 at intervals of 0.05. This set of values may be used in conjunction with tables of functions of $(1/L)^n$ to provide for those cases where values of L are not found in the tables. For example if L is equal to 2.5 then:

$$(1/2.5)^n = (1/5)^n (1/0.5)^n$$

the value of which is readily obtained from the tabular data.

The range of values for the temperature factor has been extended, to more nearly cover the range of conditions found in practice.

The effects of elevation upon pressures in the gas pipe line, may, in mountainous terrain, require that observed pressures be corrected before the accepted flow formulae may be applied. Quite often when flow is downgrade, the observed downstream pressure may equal, or exceed, the observed upstream pressure.

If a significant difference in elevation exists between the points at which pressures are observed, then these observed pressures must be corrected. The following formula was found to give satisfactory results on a section of line in the eastern United States.

$$\log P_L = \log P_H + 0.000015652 \cdot G \cdot 1/Z \cdot E \cdot (520/460 + t)$$

Where:

P_L = pressure at lowest point, psia
P_H = pressure at highest point, psia
G = specific gravity (air = 1)
E = difference in elevation, ft
Z = compressibility factor
t = line temperature, F

This formula gives accurate results for a shut-in line. In the case of a line that is in service it will not be exact, but will allow reasonably good results if used in connection with an experience factor.

There are two ways in which the observed pressures may be corrected. The choice of method will depend upon the calculator, either being satisfactory. The first of these methods is as follows:

Let $P_L - P_H = p_e$

In the case of flow downgrade, that is, with the point at which P_1 is observed at a greater elevation than the point of observation of P_2, assume:

$${}_oP_1 = P_1$$

Then:

$${}_oP_2 - p_e = P_2$$

So that:

$$P_1 + P_2 = {}_oP_1 + {}_oP_2 - p_e$$

And:

$$P_1 - P_2 = {}_oP_1 - {}_oP_2 + P_e$$

So that:

$$(P_1^2 - P_2^2)^n = ({}_oP_1 + {}_oP_2 - p_e)^n \ ({}_oP_1 - {}_oP_2 + p_e)^n$$

In a similar manner for flow upgrade, it may be shown that:

$$(P_1^2 - P_2^2)^n = ({}_oP_1 + {}_oP_2 - p_e)^n \ ({}_oP_1 - {}_oP_2 + p_e)^n$$

The method suggested above does not allow use of tabulated data. For convenience the writer has adopted the following method.

Since:

$$\log P_L = \log P_H + 0.000015652 \cdot G \cdot 1/Z \cdot (520/T)$$

We may write:

$$\log N = 0.000015652 \cdot G \cdot E \cdot 1/Z \cdot (520/T)$$

Then:

$$P_L = P_H \cdot N$$

And:

$$P_H = P_L \cdot 1/N$$

As the value of Z will vary with both pressure and temperature, the writer has preferred to tabulate values of 1/N for various values of E and G with the factors 1/Z and 520/T assumed equal to unity. This table is included in the data accompanying this article.

In using the table it should be noted that if the value of 1/N is needed for a value of E that is not tabulated, it may be found as in the following example:

Let it be required to determine the value of 1/N for an elevation of 3368 ft and a gravity of 0.686. Find the values of 1/N for G = 0.650

at 3000 ft = 0.932135
at 300 ft = 0.993012
at 60 ft = 0.998596
at 8 ft = 0.999813

The product of these values is the factor desired for G = 0.650 and the stated value of E, or in this case 1/N = 0.924149.

Proceed in a like manner to obtain the value of 1/N for G = 0.700 and the stated value of E, or 1/N = 0.918542.

Now interpolate between these values of 1/N for G = 0.686 and find the desired value of 1/N to be 0.920118.

This value, although not exact, is well within practical limits. The value as found from the formula is 0.920104.

Actually, for use in the flow formulae, such refinements are hard to justify in practice. In the example used above, if the

gravity were rounded off as 0.7 and the elevation as 3400 ft the value of 1/N would be 0.917801.

For a line pressure of 600 psia the resulting error would be:

$$(600 \cdot 0.920104) - (600 \cdot 0.915801) = 2.58 \text{ psi}$$

For similar reasons the corrections for variations in values of Z and t are not tabulated. If the calculator wishes to include these factors, the value of 1/N may be found from the formula for the existing conditions, or in the following manner:

Since:

$$\log N = 0.000015652 \text{ GE } 1/Z\ 520/T$$

and since the tabulated values are set up with

$$1/Z\ 520/T = 1$$

let the tabulated value be $1/N_t$ and the desired value be 1/N.

Then, since:

$$\log N = \log N_t \cdot 1/Z \cdot 520/T$$

Or:

$$N = N_t^{\left(1/Z \cdot \frac{520}{T}\right)} = N_t^{\frac{520}{ZT}} = N_t^{\frac{520}{460Z + Zt}}$$

As example of the effect of inclusion, or non-inclusion, of the corrections for Z and T, assume the added conditions of Z = 0.893 and t = 73:

$$1/N = 1/N_t^{\frac{520}{475.87}} = {}^{1}/N_t^{\,1.0927}$$

Or:

$$0.920118^{1.0927} = 0.913044$$

At 600 psia this will make a difference of 4.25 psi.

The actual values are, of course, used in the term $(P_1^2 - P_2^2)^n$. If the correction is to be applied to P_2 and the value of P_1 is 650 the value of the term with Z and t neglected is found to be:

$$F_1 = 343.10$$

And with these factors included:

$$F_2 = 349.84$$

The difference is:

$$F_2 - F_1 = 6.47 \text{ or about } 1.8 \text{ per cent.}$$

The individual calculator must decide whether the additional labor is, or is not, justified. It is the opinion of the writer that in general the use of the experience factor, E, may be used to include the errors resulting from simplifying the terms of the expression and held constant for a given section of line, even though the numerical value of E varies more from one section of line to another than flow conditions alone would indicate.

If pressures and/or volumes vary widely in operating a given line, then every effort should be made to determine the value of E as accurately as possible. On the other hand if the line operates at more or less steady rates, such refinements may not be justified, and in such cases E may be given a value that includes known inaccuracies.

Failure to take the effects of differences in elevation into account may lead the unwary calculator into grave errors in estimating gas in storage. It has been shown that in the case of a level line the average pressure may be found from:

$$P_{avg} = 2/3\left(P_1 + P_2 - \frac{P_1 P_2}{P_1 + P_2}\right)^*$$

In the case of a line of uniform gradient this formula will give satisfactory results, but in the case of a line that crosses mountainous terrain serious errors may result. Take as an example a line that follows a river valley over much of its length and which then abruptly changes grade to reach a terminal upon a plateau, an average pressure based upon the

*F. F. Richardson, *The Petroleum Engineer*, July, 1945.

COATING & WRAPPING MACHINE
STATIONARY COATING & WRAPPING MACHINE
CLEANING & PRIMING MACHINE
INTERNAL LINE-UP CLAMP
PIPELINE DITCH PADDER
KETTLES
STATIONARY CLEANING & PRIMING MACHINE
PATCH KETTLES
CUTTING & BEVELING MACHINE
ROAD BORING MACHINE
PIPE CRADLE
PIPE ROLLING RIG
CROSE—LITTLEFORD
MODEL 211-10-P2
PIPE LINE KETTLE
10 barrel capacity, complete with hydraulically controlled agitator, and
For transporting on highway
adjustable low pressure burner, self starting air cooled engine. Especially designed for contractors, or companies, who require an efficient heating kettle with less capacity, or as an auxiliary patch kettle for "Big Irish" jobs. This kettle is at home on the highway or tough pipeline terrain.
For tough pipeline terrain
M. J. Crose Manufacturing Company, Inc.
2715 DAWSON ROAD • TULSA, OKLAHOMA • PHONE MAdison 6-2172
New York, N. Y. Ph. BRyant 9-2236 • *Denver, Colorado Ph. EMpire 6-0332
*Houston, Texas Ph. UNderwood 9-3358 • *Newark, N. J. Ph. MArket 4-3650
DISTRIBUTOR: *CROSE-CURRAN LTD. — EDMONTON, ALBERTA — PHONE 3-5135
*Warehouses in 4 locations

formula and using the terminal pressures only may be in considerable error.

In calculating storage, the formula:

$$Q = 2Pd^2$$

Where:

Q = cu ft per mile
P = average pressure, psi
d = internal diameter, in.

gives reasonably good results for field use, and will be used in this example.

Assume the following conditions: The line is 12 in., with a total length of 60 miles, 52 miles of which are fairly level and the final section of which reaches an elevation such that $p_e = 25$. Let $P_L = 600$ and $P_H = 570$, under conditions of no flow.

Based upon terminal pressures and with no consideration of the profile:

$$P_{avg} = 2/3\left(600 + 570 - \frac{600 \cdot 570}{600 + 570}\right) = 585.1$$

If the line is considered in two sections, for the 52-mile section:

$$P_{avg} = 2/3\left(600 + 595 - \frac{600 \cdot 595}{600 + 595}\right) = 597.5$$

and for the final 8-mile section:

$$P = 2/3\left(595 + 570 - \frac{595 \cdot 570}{595 + 570}\right) = 582.6$$

Calculating storage based upon terminal pressures only:

$$Q = 2(585.1)\,(144)\,(60) = 10{,}110{,}528 \text{ ft}^3$$

Storage with consideration of profile of the line:

$$Q = 2(597.5)\,(144)\,(52) + 2(582.6)\,(144)\,(8)$$
$$= 8{,}948{,}160 + 1{,}342{,}310 = 10{,}290{,}470 \text{ ft}^3$$

It is evident that the profile of the line may have a marked effect upon the storage capacity.

If possible a pressure profile of the line should be obtained by observation, and this profile compared with the calculated pressures based upon the physical profile. In the event of any marked discrepancies every effort should be made to determine the reason.

Values of $(1/T)^{1/2}$ for various values of t.

t	$\sqrt{1/T}$	t	$\sqrt{1/T^*}$
81	0.0042993	113	0.0041776
82	0.0042954	114	0.0041739
83	0.0042914	115	0.0041703
84	0.0042875	116	0.0041667
85	0.0042835	117	0.0041630
86	0.0042796	118	0.0041594
87	0.0042757	119	0.0041558
88	0.0042718	120	0.0041523
89	0.0042679	121	0.0041487
90	0.0042640	122	0.0041451
91	0.0042601	123	0.0041416
92	0.0042563	124	0.0041381
93	0.0042524	125	0.0041345
94	0.0042486	126	0.0041310
95	0.0042448	127	0.0041274
96	0.0042409	128	0.0041239
97	0.0042371	129	0.0041204
98	0.0042333	130	0.0041169
99	0.0042296	131	0.0041134
100	0.0042258	132	0.0041100
101	0.0042220	133	0.0041065
102	0.0042182	134	0.0041030
103	0.0042145	135	0.0040996
104	0.0042108	136	0.0040962
105	0.0042070	137	0.0040927
106	0.0042028	138	0.0040893
107	0.0041996	139	0.0040859
108	0.0041959	140	0.0040825
109	0.0041922	141	0.0040785
110	0.0041885	142	0.0040757
111	0.0041849	143	0.0040723
112	0.0041812		

*T = 460 + t

Values of $\sqrt{1/G}$ for various values of G.

G		G	
0.621	1.26897	0.660	1.23091
0.622	1.26795	0.661	1.22998
0.623	1.26694	0.662	1.22905
0.624	1.26592	0.663	1.22812
0.625	1.26491	0.664	1.22720
0.626	1.26390	0.665	1.22628
0.627	1.26289	0.666	1.22536
0.628	1.26188	0.667	1.22444
0.629	1.26089	0.668	1.22355
0.630	1.25988	0.669	1.22260
0.631	1.25888	0.670	1.22170
0.632	1.25788	0.671	1.22078
0.633	1.25689	0.672	1.21988
0.634	1.25590	0.673	1.21897
0.635	1.25494	0.674	1.21806
0.636	1.25392	0.675	1.21716
0.637	1.25293	0.676	1.21626
0.638	1.25195	0.677	1.21550
0.639	1.25097	0.678	1.21446
0.640	1.25	0.679	1.21357
0.641	1.24902	0.680	1.21268
0.642	1.24805	0.681	1.21173
0.643	1.24708	0.682	1.21090
0.644	1.24611	0.683	1.21000
0.645	1.24514	0.684	1.20913
0.646	1.24418	0.685	1.20824
0.647	1.24321	0.686	1.20736
0.648	1.24226	0.687	1.20650
0.649	1.24130	0.688	1.20560
0.650	1.24034	0.689	1.20473
0.651	1.23939	0.690	1.20386
0.652	1.23847	0.691	1.20300
0.653	1.23750	0.692	1.20210
0.654	1.23654	0.693	1.20125
0.655	1.23560	0.694	1.20040
0.656	1.23466	0.695	1.19952
0.657	1.23375	0.696	1.19860
0.658	1.23278	0.697	1.19780
0.659	1.23184	0.698	1.19697
		0.699	1.19610
		0.700	1.19523

Values of $\sqrt{n}$ for various values of n.

n	$\sqrt{n}$	n	$\sqrt{n}$	n	$\sqrt{n}$
10	3.1613	670	25.8844	1330	36.4691
20	4.4721	680	26.0768	1340	36.6060
30	5.4772	690	26.2679	1350	36.7423
40	6.3246	700	26.4575	1360	36.8781
50	7.0711	710	26.6458	1370	37.0135
60	7.7460	720	26.8328	1380	37.1483
70	8.3666	730	27.0185	1390	37.2827
80	8.9443	740	27.2029	1400	37.4165
90	9.4868	750	27.3861	1410	37.5499
100	10.0000	760	27.5681	1420	37.6828
110	10.4881	770	27.7489	1430	37.8153
120	10.9545	780	27.9285	1440	37.9473
130	11.4018	790	28.1069	1450	38.0788
140	11.8322	800	28.2843	1460	38.2099
150	12.2474	810	28.4605	1470	38.3405
160	12.6491	820	28.6356	1480	38.4707
170	13.0384	830	28.8097	1490	38.6005
180	13.4164	840	28.9828	1500	38.7298
190	13.7840	850	29.1548	1510	38.8587
200	14.1421	860	29.3258	1520	38.9871
210	14.4914	870	29.4958	1530	39.1152
220	14.8324	880	29.6648	1540	39.2428
230	15.1658	890	29.8329	1550	39.3700
240	15.4919	900	30.0000	1560	39.4968
250	15.8114	910	30.1662	1570	39.6232
260	16.1245	920	30.3315	1580	39.7492
270	16.4317	930	30.4959	1590	39.8748
280	16.7332	940	30.6594	1600	40.0000
290	17.0294	950	30.8221	1610	40.1248
300	17.3205	960	30.9839	1620	40.2492
310	17.6068	970	31.1448	1630	40.3731
320	17.8885	980	31.3050	1640	40.4969
330	18.1659	990	31.4643	1650	40.6201
340	18.4391	1000	31.6228	1660	40.7430
350	18.7083	1010	31.7805	1670	40.8656
360	18.9737	1020	31.9374	1680	40.9878
370	19.2354	1030	32.0936	1690	41.1096
380	19.4936	1040	32.2490	1700	41.2310
390	19.7484	1050	32.4037	1710	41.3521
400	20.0000	1060	32.5576	1720	41.4728
410	20.2485	1070	32.7109	1730	41.5932
420	20.4939	1080	32.8634	1740	41.7133
430	20.7364	1090	33.0151	1750	41.8330
440	20.9762	1100	33.1662	1760	41.9523
450	21.2132	1110	33.3167	1770	42.0713
460	21.4476	1120	33.4664	1780	42.1900
470	21.6795	1130	33.6155	1790	42.3083
480	21.9089	1140	33.7639	1800	42.4264
490	22.1359	1150	33.9117	1810	42.5440
500	22.3607	1160	34.0588	1820	42.6614
510	22.5832	1170	34.2052	1830	42.7785
520	22.8035	1180	34.3512	1840	42.8952
530	23.0217	1190	34.4964	1850	43.0116
540	23.2379	1200	34.6410	1860	43.1277
550	23.4521	1210	34.7850	1870	43.2434
560	23.6643	1220	34.9284	1880	43.3589

Value of $\sqrt{n}$ for various values of n.

570	23.8747	1230	35.1322	1890	43.4741
580	24.0832	1240	35.2136	1900	43.5889
590	24.2899	1250	35.3553	1910	43.7035
600	24.4949	1260	35.4964	1920	43.8178
610	24.6982	1270	35.6370	1930	43.9317
620	24.8998	1280	35.7770	1940	44.0454
630	25.0998	1290	35.9165	1950	44.1588
640	25.2982	1300	36.0555	1960	44.2718
650	25.4951	1310	36.1939	1970	44.3846
660	25.6905	1320	36.3317	1980	44.4971
				1990	44.6094
				2000	44.7213

Values of $d^{2.6667}$ for various values of d.

Nominal	Schd. No.	O.D.	I.D.	t	$d^{2.6667}$
2	40	2.375	2.067	0.154	5.9330
			2.041	0.167	5.7028
			2.000	0.188	5.3498
	80		1.939	0.218	5.8463
			1.875	0.250	5.3458
			1.750	0.312	4.4474
	160		1.689	0.343	4.0459
			1.503	0.436	2.9641
3		3.500	3.350	0.125	23.1760
			3.204	0.148	22.3116
			3.124	0.188	20.8567
	40		3.068	0.216	19.8746
			3.018	0.241	19.0225
			2.992	0.254	18.5886
			2.922	0.289	17.4514
	80		2.900	0.300	17.1032
			2.875	0.312	16.7128
			2.687	0.406	13.9550
	160		2.626	0.437	13.1260
			2.300	0.600	9.2176
4		4.500	4.244	1 0.28	47.2195
			4.232	0.134	46.8608
			4.216	0.142	46.3898
			4.170	0.165	45.0523
			4.124	0.188	43.7392
			4.090	0.205	42.7841
	40		4.026	0.237	41.0220
			4.000	0.250	40.3193
			3.958	0.271	39.2002
			3.938	0.281	38.6742
			3.900	0.300	37.6870
			3.876	0.312	37.0718
	80		3.826	0.337	35.8102
			3.750	0.375	33.9445
	120		3.626	0.437	31.0332
			3.500	0.500	28.2401
			3.438	0.531	26.9257
			3.152	0.674	21.3589
6		6.625	6.287	0.169	134.651
			6.265	0.180	133.398
			6.249	0.188	132.492
			6.187	0.219	129.015
			6.125	0.250	125.596
			6.071	0.277	122.665
	40		6.065	0.280	122.342
			5.875	0.375	112.383
	80		5.761	0.432	106.664
			5.625	0.500	100.081
	120		5.501	0.562	94.305
	160		5.189	0.718	80.708
			4.897	0.864	69.137
8		8.625	8.309	0.158	283.244
			8.295	0.165	281.973
			8.249	0.188	277.832
			8.219	0.203	275.136
			8.187	0.219	272.289
			8.149	0.238	268.932
	20		8.125	0.250	266.825
	30		8.071	0.277	262.122
	40		7.981	0.322	254.399
			7.937	0.344	250.677
			7.921	0.352	249.331
			7.875	0.375	245.489
	60		7.813	0.406	240.365
			7.687	0.469	230.700
	80		7.625	0.500	225.282
	100		7.439	0.593	210.411
			7.375	0.625	205.618
	120		7.189	0.718	192.521
	140		7.001	0.812	179.382
			6.875	0.875	170.905
	160		6.813	0.906	166.823
10		10.750	10.374	0.188	511.945
			10.344	0.203	508.007
			10.310	0.219	503.567
	20		10.250	0.250	495.790
			10.192	0.279	488.343
	30		10.136	0.307	481.221
			10.054	0.348	470.909
	40		10.020	0.365	466.674
			9.960	0.395	459.260
	60		9.750	0.500	433.889
			9.687	0.531	426.453
	80		9.564	0.593	412.165
	100		9.314	0.718	384.057
			9.250	0.750	377.060
	120		9.064	0.843	357.179
	140		8.750	1.000	335.137
			8.625	1.063	312.888
	160		8.500	1.125	300.941

Values of $\sqrt{1/n}$ for various values of n.

n	$\sqrt{1/n}$	n	$\sqrt{1/n}$
0.05	4.47214	0.55	1.34840
0.10	3.16222	0.60	1.29100
0.15	2.58199	0.65	1.24037
0.20	2.23607	0.70	1.19523
0.25	2.00000	0.75	1.15470
0.30	1.82574	0.80	1.11803
0.35	1.69031	0.85	1.08465
0.40	1.58114	0.90	1.05167
0.45	1.49071	0.95	1.02598
0.50	1.41421	1.00	1.00000

Values of $1/n^{0.5394}$ for various values of n.

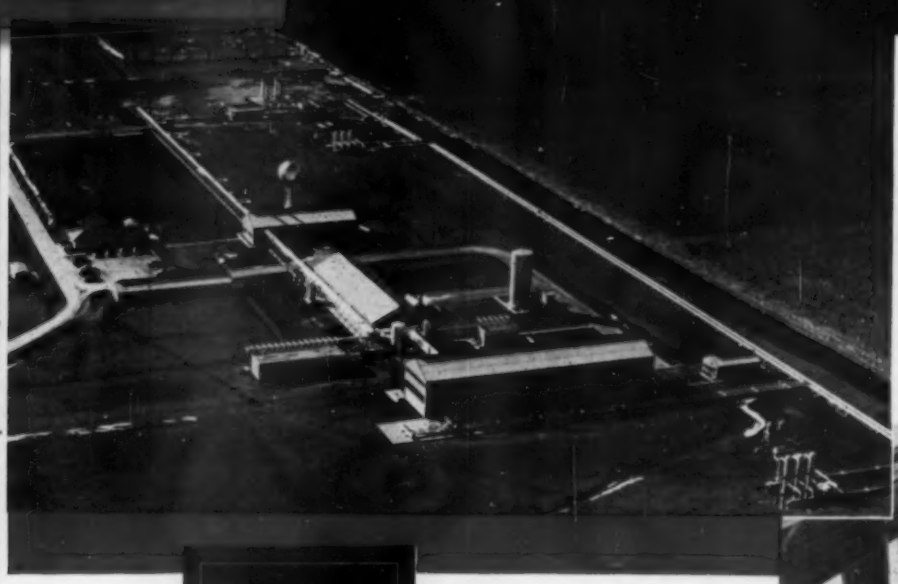
n		n	
0.05	5.03240	0.55	1.38039
0.10	3.46258	0.60	1.31724
0.15	2.78235	0.65	1.26449
0.20	2.38300	0.70	1.21217
0.25	2.11228	0.75	1.16786
0.30	1.91399	0.80	1.12788
0.35	1.76269	0.85	1.09162
0.40	1.63926	0.90	1.05848
0.45	1.53834	0.95	1.02805
0.50	1.45337	1.00	1.00000

Values of N where $\log N = 0.000015652\ G\ E$, for various values of G and E.

E	G = 0.6	G = 0.65	G = 0.7	G = 0.75	G = 0.8
1	0.999978	0.999977	0.999975	0.999973	0.999970
2	0.999957	0.999953	0.999950	0.999946	0.999942
3	0.999935	0.999930	0.999924	0.999919	0.999913
4	0.999913	0.999906	0.999899	0.999892	0.999885
5	0.999892	0.999883	0.999874	0.999865	0.999856
6	0.999870	0.999859	0.999849	0.999838	0.999827
7	0.999849	0.999836	0.999823	0.999811	0.999797
8	0.999827	0.999813	0.999798	0.999784	0.999770
9	0.999806	0.999789	0.999773	0.999757	0.999740
10	0.999784	0.999766	0.999748	0.999730	0.999712
20	0.999567	0.999531	0.999495	0.999460	0.999424
30	0.999351	0.999296	0.999243	0.999189	0.999136
40	0.999135	0.999064	0.998991	0.998920	0.998847
50	0.998919	0.998830	0.998740	0.998650	0.998560
60	0.998704	0.998596	0.998488	0.998380	0.998272
70	0.998488	0.998361	0.998236	0.998110	0.997984
80	0.998272	0.998128	0.997984	0.997840	0.997696
90	0.998056	0.997894	0.997732	0.997570	0.997408
100	0.997840	0.997660	0.997480	0.997301	0.997121
200	0.995684	0.995326	0.994967	0.994610	0.994250
300	0.993534	0.993012	0.992490	0.991924	0.991388
400	0.991388	0.990673	0.989960	0.989246	0.988533
500	0.989246	0.988355	0.987465	0.986576	0.985688
600	0.987109	0.986043	0.984967	0.983913	0.982850
700	0.984977	0.983736	0.982495	0.981257	0.980020
800	0.982850	0.981434	0.980020	0.978608	0.977198
900	0.980726	0.979137	0.977550	0.975966	0.974385
1000	0.978608	0.976846	0.975088	0.973332	0.971580
2000	0.957674	0.954229	0.950796	0.947375	0.943970
3000	0.937187	0.932135	0.927109	0.922111	0.917139
4000	0.917139	0.910552	0.904013	0.897520	0.891074
5000	0.897520	0.889470	0.881491	0.873585	0.865749
6000	0.878330	0.868875	0.859536	0.850288	0.841144

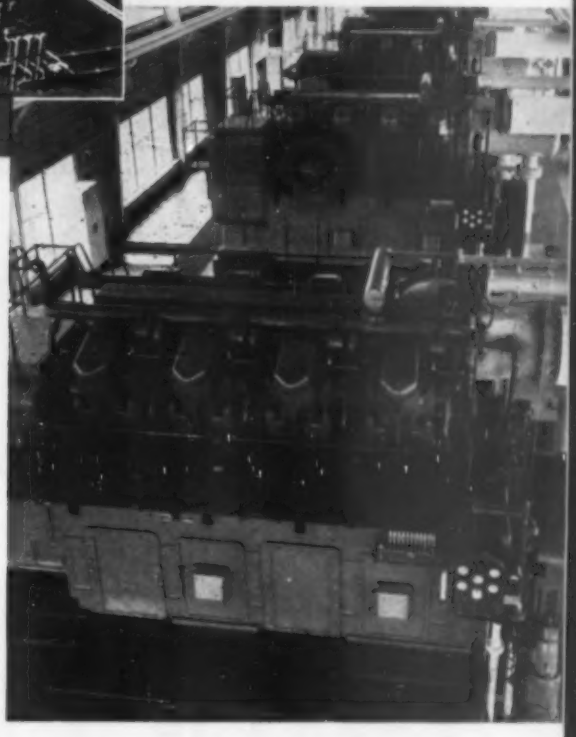
Values of $(520/460 + t)^{0.5394}$ for various values of t.

t		t	
81	0.97887	114	0.94810
82	0.97790	115	0.94721
83	0.97692	116	0.94632
84	0.97589	117	0.94544
85	0.97499	118	0.94456
86	0.97043	119	0.94368
87	0.97306	120	0.94280
88	0.97211	121	0.94192
89	0.97115	122	0.94105
90	0.97020	123	0.94018
91	0.96925	124	0.93931
92	0.96830	125	0.93844
93	0.96736	126	0.93785
94	0.96641	127	0.93672
95	0.96547	128	0.93586
96	0.96454	129	0.93500
97	0.96360	130	0.93414
98	0.96267	131	0.93329
99	0.96174	132	0.93244
100	0.96081	133	0.93159
101	0.95989	134	0.93075
102	0.95897	135	0.92990
103	0.95805	136	0.92906
104	0.95713	137	0.92823
105	0.95622	138	0.92738
106	0.95531	139	0.92655
107	0.95440	140	0.92572
108	0.95349	141	0.92488
109	0.95259	142	0.92406
110	0.95168	143	0.92323
111	0.95079		
112	0.94989		
113	0.94899		



This underground storage development is operated by the Natural Gas Storage Co. which is under common management of Natural Gas Pipeline Co. of America and Texas Illinois Natural Gas Pipeline Co., subsidiaries of Peoples Gas Light & Coke Co., Chicago. Five Cooper-Bessemer compressors, each rated 2000 hp at 250 rpm, are operating in this giant gas storage field.

This overhead view of GMW's in Herschor Station 201 shows the neat, compact arrangement of 10,000 Cooper-Bessemer horsepower.



Another Example of Efficient Power at Lower Cost

AT HERSCHER UNDERGROUND STORAGE ....

The same Cooper-Bessemers for INJECTION and WITHDRAWAL

● At Herscher Dome's 90 billion cubic foot capacity gas storage pool the main compressor station, 201, houses five giant 2000 hp Cooper-Bessemer GMW engine-driven compressors.

Equipped with suction and discharge headers designed to permit expansion to 32,000 hp if necessary, this modern station can be enlarged to three times its present capacity with minimum modification and at low cost. In addition to injecting southwest gas into storage, the same GMW units can be used for withdrawing and recompressing the gas for transmission to the Chicago area. This is made possible through a unique arrangement which permits the reversal of the gas flow using the same compressor piping for both cycles.

Besides GMW compressors, two 8-cylinder Cooper-Bessemer JS engines are used to drive 500-kva generators for dependable electric service for the entire station.

Whether it's power for compression or any other type service, Cooper-Bessemer heavy-duty units are the economical buy for: flexibility, availability, low-cost operation and minimum maintenance. Contact the nearest Cooper-Bessemer sales and engineering office for complete information.

MOUNT VERNON, OHIO

COOPER-BESSEMER

GROVE CITY, PENNA.

New York City • Seattle, Wash. • Bradford, Pa. • Chicago, Ill. Houston, Dallas, Greggton, Pampa and Odessa, Texas Washington, D. C. • Shreveport, La. • San Francisco, Los Angeles, Calif. • St. Louis, Mo. • Gloucester, Mass. • New Orleans, La. • Tulsa, Okla. • Cooper-Bessemer of Canada Ltd., Edmonton, Alberta—Halifax, Nova Scotia.

DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

Values of $(0.6/G)^{0.4666}$ for various values of G.

G		G	
0.621	0.99477	0.663	0.96524
0.622	0.99404	0.664	0.96457
0.623	0.99330	0.665	0.96390
0.624	0.99257	0.666	0.96323
0.625	0.99179	0.667	0.96256
0.626	0.99111	0.668	0.96190
0.627	0.99038	0.669	0.96124
0.628	0.98965	0.670	0.96058
0.629	0.98893	0.671	0.95992
0.630	0.98820	0.672	0.95926
0.631	0.98748	0.673	0.95860
0.632	0.98676	0.674	0.95795
0.633	0.98604	0.675	0.95729
0.634	0.98543	0.676	0.95664
0.635	0.98472	0.677	0.95599
0.636	0.98390	0.678	0.95534
0.637	0.98319	0.679	0.95469
0.638	0.98248	0.680	0.95404
0.639	0.98177	0.681	0.95340
0.640	0.98106	0.682	0.95276
0.641	0.98036	0.683	0.95211
0.642	0.97965	0.684	0.95147
0.643	0.97895	0.685	0.95083
0.644	0.97825	0.686	0.95019
0.645	0.97755	0.687	0.94956
0.646	0.97685	0.688	0.94892
0.647	0.97616	0.689	0.94828
0.648	0.97546	0.690	0.94765
0.649	0.97477	0.691	0.94702
0.650	0.97408	0.692	0.94639
0.651	0.97339	0.693	0.94576
0.652	0.97270	0.694	0.94513
0.653	0.97202	0.695	0.94450
0.654	0.97133	0.696	0.94388
0.655	0.97056	0.697	0.94326
0.656	0.96997	0.698	0.94263
0.657	0.96929	0.699	0.94201
0.658	0.96859	0.700	0.94139
0.659	0.96793		
0.660	0.96725		
0.661	0.96658		
0.662	0.96591		

Values of $n^{0.5394}$ for various values of n.

10	3.4626	650	33.7174	1350	48.8092
20	5.0324	660	33.9840	1360	49.0039
30	6.2627	700	34.2488	1370	49.1979
40	7.3140	710	34.5118	1380	49.3913
50	8.2494	720	34.7732	1390	49.5840
60	9.1020	730	35.0329	1400	49.7761
70	9.8911	740	35.2909	1410	49.9676
80	10.6298	750	35.5474	1420	50.1584
90	11.3271	760	35.8022	1430	50.3487
100	11.9894	770	36.0556	1440	50.5383
110	12.6219	780	36.3074	1450	50.7273
120	13.2282	790	36.5578	1460	50.9157
130	13.8121	800	36.8066	1470	51.1035
140	14.3754	810	37.0541	1480	51.2907
150	14.9205	820	37.3002	1490	51.4774
160	15.4498	830	37.5448	1500	51.6634
170	15.9626	840	37.7882	1510	51.8489
180	16.4624	850	38.0301	1520	52.0339
190	16.9496	860	38.2708	1530	52.2182
200	17.4251	870	38.5102	1540	52.4020
210	17.8895	880	38.7484	1550	52.5853
220	18.3443	890	38.9853	1560	52.7681
230	18.7463	900	39.2208	1570	52.9502
240	19.2258	910	39.4554	1580	53.1319
250	19.6539	920	39.6887	1590	53.3130
260	20.0741	930	39.9208	1600	53.4935
270	20.4869	940	40.1518	1610	53.6737
280	20.8928	950	40.3816	1620	53.8533
290	21.2920	960	40.6103	1630	54.0323
300	21.6849	970	40.8380	1640	54.2109
310	22.0719	980	41.0645	1650	54.3889
320	22.4531	990	41.2900	1660	54.5665
330	22.8289	1000	41.5145	1670	54.7435
340	23.1995	1010	41.7379	1680	54.9201
350	23.5651	1020	41.9603	1690	55.0962
360	23.9259	1030	42.1817	1700	55.2718
370	24.2821	1040	42.4021	1710	55.4470
380	24.6340	1050	42.6216	1720	55.6216
390	24.9816	1060	42.8400	1730	55.7958
400	25.3250	1070	43.0575	1740	55.9696
410	25.6647	1080	43.2741	1750	56.1428
420	26.0004	1090	43.4892	1760	56.3157
430	26.3325	1100	43.7046	1770	56.4880
440	26.6611	1110	43.9184	1780	56.6599
450	26.9862	1120	44.1314	1790	56.8316
460	27.3081	1130	44.3435	1800	57.0025
470	27.6267	1140	44.5547	1810	57.1731
480	27.9422	1150	44.7652	1820	57.3432
490	28.2547	1160	44.9747	1830	57.5130
500	28.5643	1170	45.1834	1840	57.6823
510	28.8711	1180	45.3923	1850	57.8511
520	29.1750	1190	45.5985	1860	58.0196
530	29.4764	1200	45.8047	1870	58.1877
540	29.7750	1210	46.0102	1880	58.3553
550	30.0712	1220	46.2149	1890	58.5225
560	30.3649	1230	46.4189	1900	58.6894
570	30.6562	1240	46.6220	1910	58.8558
580	30.9451	1250	46.8245	1920	59.0218
590	31.2318	1260	47.0263	1930	59.1874
600	31.5162	1270	47.2271	1940	59.3526
610	31.7985	1280	47.4273	1950	59.5175
620	32.0786	1290	47.6268	1960	59.6819
630	32.3567	1300	47.8256	1970	59.8459
640	32.6327	1310	48.0582	1980	60.0096
650	32.9067	1320	48.2211	1990	60.1729
660	33.1788	1330	48.4178	2000	60.3358
670	33.4491	1340	48.6138		

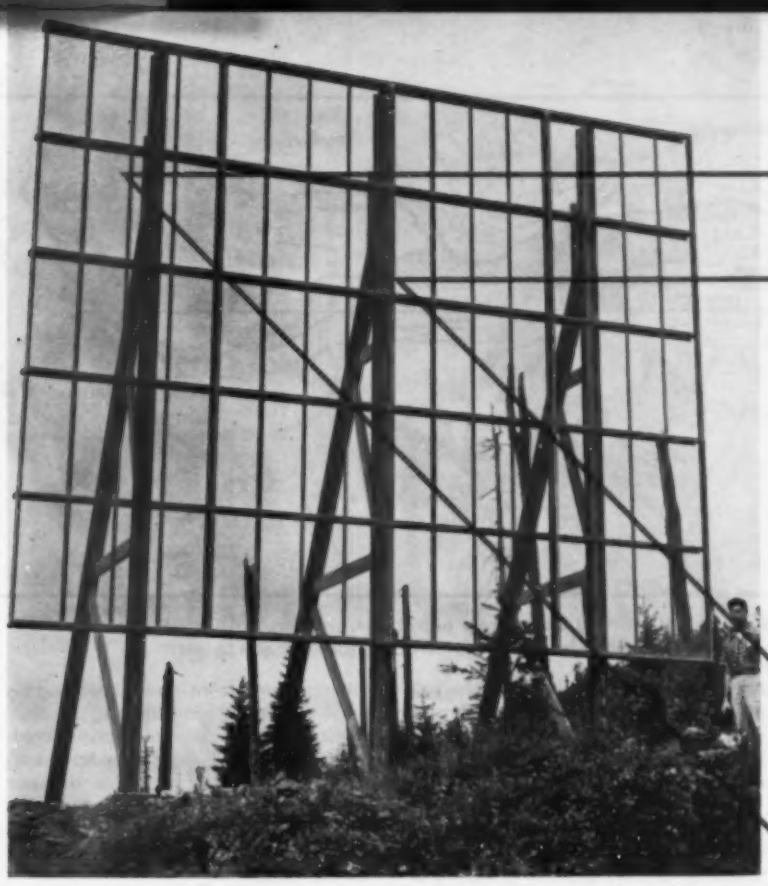
Values of $n^{0.5394}$ for various values of n.

570	30.6562	1240	46.6220	1910	58.8558
580	30.9451	1250	46.8245	1920	59.0218
590	31.2318	1260	47.0263	1930	59.1874
600	31.5162	1270	47.2271	1940	59.3526
610	31.7985	1280	47.4273	1950	59.5175
620	32.0786	1290	47.6268	1960	59.6819
630	32.3567	1300	47.8256	1970	59.8459
640	32.6327	1310	48.0582	1980	60.0096
650	32.9067	1320	48.2211	1990	60.1729
660	33.1788	1330	48.4178	2000	60.3358
670	33.4491	1340	48.6138		

Values of $d^{2.6182}$ for various values of d.

Nominal	Schd. No.	O.D.	I.D.	t	$d^{2.6182}$
2	40	2.375	2.067	0.154	6.6931
			2.041	0.167	6.4749
			2.000	0.188	6.1398
	80		1.939	0.218	5.6616
			1.875	0.250	5.1853
			1.750	0.312	4.3284
	160		1.689	0.343	3.9441
			1.503	0.436	2.9061
3		3.500	3.250	0.125	21.8884
			3.204	0.148	21.0865
			3.124	0.188	19.7357
	40		3.068	0.216	18.8230
			3.018	0.241	18.0302
			2.992	0.254	17.6264
			2.922	0.289	16.5670
	80		2.900	0.300	16.2424
			2.875	0.312	15.8783
			2.687	0.406	13.3018
	160		2.626	0.437	12.5256
			2.300	0.600	8.8527
4		4.500	4.244	0.128	44.0192
			4.232	0.134	43.6940
			4.216	0.142	43.2628
			4.170	0.165	42.0378
			4.124	0.188	40.8345
			4.090	0.205	39.9599
	40		4.026	0.237	38.3425
			4.000	0.250	37.6976
			3.958	0.271	36.6700
			3.938	0.281	36.1869
			3.900	0.300	35.2797
			3.876	0.312	34.7141
	80		3.826	0.337	33.5539
			3.750	0.375	33.1840
	120		3.626	0.437	29.1537
			3.500	0.500	26.5753
			3.438	0.531	25.3604
			3.152	0.674	20.2022
6		6.625	6.287	0.169	123.164
			6.265	0.180	122.039
			6.249	0.188	121.225
			6.187	0.219	118.101
			6.125	0.250	115.027
			6.071	0.277	112.391
	40		6.065	0.280	112.101
			5.875	0.375	103.137
	80		5.761	0.432	97.980
			5.625	0.500	92.039
	120		5.501	0.562	86.821
	160		5.189	0.718	74.513
			4.897	0.864	64.029
8		8.625	8.309	0.158	255.601
		8.295	8.295	0.165	254.475
			8.249	0.188	250.797
			8.219	0.203	248.416
			8.187	0.219	245.892
			8.149	0.238	242.914
	20		8.125	0.250	241.046
	30		8.071	0.277	236.874
	40		7.981	0.322	230.020
			7.937	0.344	226.715
			7.921	0.352	225.520
			7.875	0.375	222.108
	60		7.813	0.406	217.555
			7.687	0.469	208.492
	80		7.625	0.500	204.117
	100		7.439	0.593	191.337
			7.375	0.625	187.488
	120		7.189	0.718	174.956
	140		7.000	0.812	163.605
			6.875	0.875	155.649
	160		6.813	0.906	152.001
10		10.750	10.374	0.188	457.036
			10.344	0.203	453.584
			10.310	0.219	449.690
	20		10.250	0.250	442.871
			10.192	0.279	436.340
	30		10.136	0.307	430.091
			10.054	0.348	421.040
	40		10.020	0.365	417.323
			9.960	0.395	410.811
	60		9.750	0.500	388.519
			9.687	0.531	381.980
	80		9.564	0.593	369.412
	100		9.314	0.718	344.861
			9.250	0.750	338.495
	120		9.064	0.843	320.963
	140		8.750	1.000	292.661
			8.625	1.063	281.841
	160		8.500	1.125	271.272

★ ★ ★



20 by 24 ft passive repeater installed to bypass mountain in microwave path. Note simple structure required for rigidity and screen-like appearance to reduce wind loading.

EXCLUSIVE

How To Use

Passive Repeaters

"Bounce Transmission" Simplifies Microwave Path Obstacle Troubles

R. H. Davis

Head, Microwave Systems Engineering Department
Motorola Communications and Electronics, Inc.

IF there were no terrain problems, microwave installations would be much simpler to plan. But often installations are planned for areas with built-in terrain problems — the same problems that make land lines difficult or expensive to install and maintain. In this type of rugged country, a large hill frequently is located squarely in the middle of the shortest microwave path between proposed stations.

In solving a problem like this, the microwave engineer is often able to use a passive repeater — a device that repeats a microwave signal without the introduction of additional power or electronic amplification. A passive repeater is nothing more than a simple metallic structure designed to provide very efficient re-radiation of microwave energy.

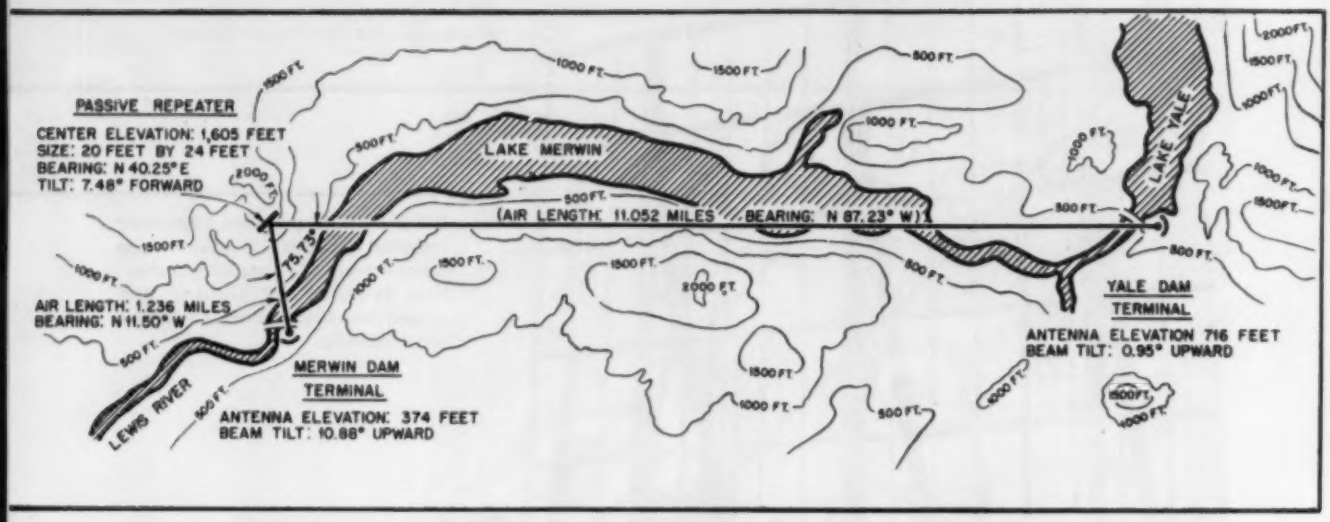
With passive repeaters, the microwave engineer can capitalize on the reflection phenomenon of microwave signals to make the microwave beam step around or up and down the highest mountain or wiggle along the snakiest valley.

Applications for Repeaters

Passive repeaters are normally used when the terrain problems are such that direct "line-of-sight" transmission cannot be obtained with practical tower heights. One of the ways to solve a problem like this would be to install a microwave station on top of the hill that is blocking the transmission path. The audio circuits are then brought down to the desired location by wire lines or radio equipment.

This approach to the problem often has many disadvantages. Wire lines are expensive to install and maintain. Unless carrier equipment is used, a pair of lines is required for each audio channel. If carrier or radio equipment is used at the remote site, provisions for power have to be made. Maintenance is difficult, of course, for these sites are often in hard-to-reach locations. Another complication is caused by extending the audio circuits, since this can result in lower circuit quality.

If there is a suitable site available, the answer to this kind of problem is the use of passive repeaters. The electronic equipment can be located close to the desired audio drop points which makes the installation substantially less expensive. Maintenance on the site of the passive repeater is normally limited to an annual expenditure, at the convenience of the weather and the per-



Map shows how 2000-foot hill blocked most direct path between microwave stations. A passive repeater on hill about a mile from end station easily solved the problem.

sonnel, to clear away the brush from the front of the repeater.

One or Two Reflectors

Passive repeaters can consist of a single reflector or a pair of reflectors installed on adjacent sites to operate as a single unit.

For best transmission results, the single repeater is usually employed if possible. Two reflectors used in a paired arrangement has some disadvantages. A minimum spacing between the two reflectors must be observed in order that the phase error in the radiation between the two does not materially affect the computed path loss. In general, a paired reflector system will introduce approximately 3 db loss from the values computed for an equivalent single reflector system.

Choosing the Location

There are two very important considerations to be studied in selecting a site for the passive reflector; *nearness to the microwave station* and *path azimuth angle*.

The efficiency of any propagation system using passive repeaters is directly related to the product of the path distances. For minimum space loss, this product should be as small as possible. In effect, this means that the closer the passive repeater can be to either of the microwave stations, the smaller the passive repeater can be.

Here is an example to illustrate this point.

Two sites, A and B, are available as a location for a passive repeater. Site A is 10 miles from one transmitter and one mile from the other. The product of the distances is 10. Site B is ½ mile from one transmitter and 10½ miles from the other. The product here is only 5¼, or approximately one-half of the other. Therefore, the effective area required for a passive repeater at Site B need be only one-half of the effective area required for Site A.

The gain of a passive repeater is directly proportional to its projected area in the direction of transmission. It therefore follows that the projected or effective area of the passive repeater is a function of the path azimuth angles involved. A passive repeater reflecting beams at a 10 deg included angle can be much smaller than one reflecting at an 80 deg included angle, by a factor of the cosine of half the angle.

Thus it can be seen that the site that provides the best "shot" at the face of the reflector is probably the better location. In fact, by selecting a hill directly behind the microwave station, very effective use of the reflector area may be made.

Transmission Characteristics

To understand the efficiency of a passive repeater, it is necessary to consider it as a radiating antenna fed from a point source in the same manner as a parabolic antenna. Passive repeaters provide a gain and beamwidth that is a function of the size and efficiency of the repeater and the uniformity of the illumination from the source. This source is the adjacent station.

Because of the distance encountered, the illumination can be considered uniform across the face. This distance should exceed D^2/λ. In theory, if the structure is large enough, its overall affect will be to contribute to the gain of the path.

Design Considerations

There are two important factors that influence the design of a passive repeater; transmission and mechanical considerations. The allowable loss helps to define the size of the reflector. The required face flatness and rigidity to withstand the effects of wind and ice influence the mechanical design.

It is generally found that the size of the passive repeater can be minimized by using the highest antenna gain available at each end of the path. It is usually more economical to add the gain at the point sources rather than use a large passive repeater. Standard antenna configurations are available to obtain maximum terminal station gain for all practical tower heights.

The structural rigidity and other related characteristics such as face flatness must be maintained within certain limits under all conditions of operation to insure continuity of optimum system performance.

In general, the structural design should withstand 30 lb wind loading (with or without ice, depending upon the climate) with nominal deflection rigidity of ±¼ the beamwidth in all directions and a flatness variation of ±⅛ wavelength across the face of the repeater.

The face sheets of the repeater can be perforated to reduce wind loading. Circular perforations of less than ⅛

The Author

Robert H. Davis has been head of the microwave systems engineering department for Motorola Communications and Electronics, Inc. for more than two years. He is a graduate of the University of Minnesota. Davis joined Motorola in 1950 as a field project engineer. It was during his work in this capacity that he installed the passive repeater for Pacific Power and Light Company.

"PAINT THE INSIDE ?"

Sure you can "paint" the inside of your pipe line, but you don't need a brush (or a scraper) with UNICOR®.

UNICOR, UOP's oil-soluble corrosion inhibitor, added at a concentration as low as 10 ppm., will in effect make a rust-preventive oil of your product.

This makes UNICOR economical, providing vital protection for your pipe line at an inhibitor cost of about $0.0005 per barrel. UNICOR will scour your pipe line and coat it with a film that repels moisture and sludge.

Economies which result from reduced scraper and filter maintenance will more than pay for the inhibitor. This means that you actually get free protection for your pipe line.

Our experienced technologists will be glad to assist you in the design, installation and operation of a UNICOR system of protection. Write us for complete information and samples.

PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD
DES PLAINES, ILLINOIS, U S. A.

You can count on SPI to give the same close attention to your delivery schedules that they give to the specifications and procedures that result in your receiving the finest coated and wrapped pipe.

Your pipe will be shipped where you want it when you want it, regardless of whether its destination is railhead or city's center. And the care and protection used in loading your pipe results in it leaving our plant in perfect condition.

standard pipeprotection inc.
3000 SOUTH BRENTWOOD BLVD. • ST. LOUIS 17, MISSOURI

wavelength make the sheet appear electrically as a solid to the microwave energy.

Structural Types

There are two general structural classifications of passive repeaters — self-supporting and guyed. Repeaters larger than 300 sq ft in area are usually self-supporting and rest on concrete piers. The perforated aluminum sheets are attached to a rigid aluminum angle frame which has aluminum supporting channels brought back to a foundation behind the face of the repeater. The sizes of the frame members, methods of bracing and fastening are all determined by wind loading and structural rigidity requirements.

If system design permits a passive repeater with a smaller face, the perforated aluminum screen can be mounted on a frame attached to a tower or between a pair of poles imbedded in a concrete foundation. Since the face of the repeater need only be high enough for "line-of-sight" clearance over brush or snow, tall poles are usually not needed, and a very economical and satisfactory installation is possible. The poles may or may not be guyed, depending on rigidity requirements.

Installation

The installation of a passive repeater generally involves no serious problem other than transporting the material to the location. Weight is minimized, since almost all material is aluminum. Erection of the structure is straightforward and can be performed by a labor crew under supervision of a competent foreman or engineer. Alignment is accomplished by focusing the antennas of the adjacent microwave stations on the face of the repeater and adjusting the angle of the repeater for optimum communication between stations.

Operation

Passive repeaters used in microwave systems have performed exceptionally well. System performance has not been affected by heavy wind and ice conditions, and except for annual brush-clearing expeditions, maintenance requirements are nil.

Conclusion

When planning microwave installations, don't overlook the possible use of passive repeaters. The flexibility provided by these non-electrical repeaters permit economical microwave installations in practically any terrain. With passive reflectors, your microwave system can skirt a formidable hill or snake along the most crooked valley . . . and do it economically. ★ ★ ★

WHY COOLING TOWERS DECAY

= How to Prevent

FIG. 1. **Internal fungus** attack of cooling tower lumber.

E. H. Hurst

Production Manager, Water Stabilization
National Aluminate Corporation

IN recent years, there has been great concern over the deterioration of cooling tower lumber and the protection of this lumber.

This is the result of serious problems that have arisen in several plants where seemingly sound cooling tower lumber has been weakened, resulting in the collapse of the cooling tower. When you consider that a cooling tower handling 5000 gpm represents an investment of several hundred thousand dollars, you can readily appreciate this concern of cooling tower operators.

Deterioration of the cooling tower lumber has been reported only recently. Little or no mention of it was made 10 or 20 years ago.

In some areas only one tower in ten is affected, whereas in other areas all towers are affected. Also, there is no singling out of any one make or style of mechanical draft tower as being more susceptible to wood deterioration than another. Deterioration is reported to be taking place in all types and makes of towers.

With these facts and experiences known to the cooling tower operator, he is even more curious as to why deterioration occurs, seemingly at random, and what steps he can take to prevent this deterioration.

To study this problem we shall review the reasons for the use of wood in cooling towers, properties the wood possesses, and what happens to the wood as it deteriorates.

First of all, wood is used almost universally in cooling towers. Its ease of construction, relatively inexpensive cost, and wide availability, make it highly suitable for cooling tower construction. Only in recent years has there been any extensive use of such materials as plastics, aluminum, or other metals.

The durability of the lumber in a cooling tower is quite remarkable considering the wide range of operating environmental conditions. In any given system, the wood is subject to a wide range of moisture content, from dry surfaces on the outside shell of the tower, high moisture in the distribution and mist elimination areas, to completely water-washed surfaces, such as the cooling tower fill and tower supports.

With this wide range of moisture content, there are also extreme variations in temperatures, from 65F in the bottom portion of the tower, perhaps even cooler in the northern area of the country in the winter, up to 150F or higher in the distribution area of the tower where the hot water is returned.

Also complicating the picture are varying types of waters, which may contain minerals that have been shown to be detrimental to lumber, concentration of which may vary throughout the tower as the result of splashing and evaporation or as a function of temperature. The flow of water may be erosive in character or non-continuous usage of the tower may, through repeated soakings and drying outs, contribute to the deterioration of the wood physically.

Certain Types of Wood Used

Because of these extreme environmental conditions that lumber must endure, generally only specific types of wood are used in tower construction. These woods have been chosen for their natural resistance to deterioration and their adaptability to the wide range of operations. The most widely used lumber for this purpose is California redwood. Other types sometimes used are cypress, fir, and pine. Even among these selected woods, only certain portions of the tree are used and only top grades of lumber are acceptable. Rigid specifications have been set up by the Cooling Tower Institute.

As California redwood greatly exceeds any other type of lumber in towers, we should consider this wood in particular, although the comments will, in general, apply to other types of lumber.

For our discussion purposes, we need to identify the constituents present in the wood, their relative amounts, and to group them, for ease of discussion, into two or three general classes.

A typical analysis of redwood will show approximately 50 per cent of the dry weight to be cellulose, which would include all types of carbohydrates, such as true cellulose and hemicellulose. The lignin content of the wood approximates 30 per cent of its dry weight. The

Presented before the Gas Technology Short Course, Texas A&I College, Kingsville, Texas, under the title "Cooling Tower Lumber Deterioration — How It Can Be Prevented."

remainder of the wood is grouped into a class that can be called extractives, which include those components of the wood soluble in solvents such as water, alcohol, or benzene. This includes a wide variety of materials and is one of the major differences between various species of wood.

Wood's Basic Components

The three basic components of the wood serve specific, but very closely integrated functions. The cellulose portions are the body of the wood, providing the fibers that give the wood its strength. The lignins serve as a binder for these fibers, contributing to the strength of the wood as cement contributes to the strength of a brick wall. The extractives include, among other things, those materials that give the wood its natural resistance to microbiological attack. These materials are toxic to wood-destroying fungi and other micro-organisms.

We have all heard various terms describing wood deterioration in a cooling tower, such as delignification, wood rot, or surface microbiological attack, and leaching. These terms describe chemical reactions that take place in the wood and actually represent reaction or attack of the basic ingredients. For instance, leaching is the removal of the extractives, microbiological rot is primarily attack of the cellulose materials, and delignification is the selective removal of the lignins. With any of these types of reactions taking place, the ratio of one constituent to the other is altered, which can result in a color change such as the white appearance of delignified wood, the dark appearance of microbiologically attacked wood, or a general lightening of color through leaching of color-producing extractives.

Causes of Deterioration

The causes of wood deterioration have been generally classified as chemical or microbiological. Many times it is difficult to distinguish between chemical and microbiological attack and more often than not they appear, if not simultaneously, closely following one another. For instance, chemical attack of the lumber may take place, depriving the wood of its natural resistance so that the wood is vulnerable to microbiological attack.

Chemical attack of cooling tower lumber results from many causes and can affect all three of the basic constituents in the lumber. We should differentiate, however, between the various types of chemical attack and their causes.

The simplest form of chemical attack is that of leaching. The leaching action removes the extractable materials present in the water as the cooling tower passes over the tower lumber. You are familiar, I am sure, with the color throw that occurs when starting up a new cooling tower system. This throw-off of color is the result of leaching of the extractable materials in the wood by the cooling tower lumber. Unfortunately, these extractable materials are those that contain the constituents that are considered to be toxic to wood-destroying organisms, and, as a result of this leaching, the natural resistance of the cooling tower lumber to microbiological deterioration is decreased.

How to Limit Leaching

To limit the amount of leaching that will occur when starting up a new system, the cooling tower should be treated to provide a neutral or slightly acid pH value. The natural environment of the lumber is slightly acidic, and by providing a pH value in the system water as close as possible to the natural environment of the tower lumber, the leaching action is held to a minimum.

Although the leaching type of attack does not result in any visual deterioration of the lumber, there are other types of chemical attack that do produce a noticeable deterioration. Probably the most well-known is delignification, which results in the removal of lignin from the tower lumber, leaving a residue that is high in cellulose content, which takes on a very white appearance. The removal of the lignin binder frees the wood fibers, giving the wood a fuzzy appearance. The strength of the wood is greatly reduced as these fibers are washed free by the erosive action of the tower water, exposing a new surface to the delignifying agent.

Delignification can be compared to the processing of wood in the paper and pulp industry and is brought about by the use of highly oxidizing materials or by alkaline materials. It has been reported that high concentrations of sodium carbonates and sodium bicarbonates can produce delignification type of attack in a cooling tower system. Although in a pulp and paper mill, we normally would think of using fairly high concentrations of carbonate or other alkaline materials for digesting the wood, the fact that we do have continuous exposure of the tower lumber to the alkaline materials over a long period of time results in a similar digestive type of attack, although occurring at a much slower rate. Also, the fact that cooling tower water evaporates and in doing so leaves a residue of salts on the wood surfaces where there is not continuous washing, the concentration of alkaline salts thus may build up to the point where serious deterioration can occur. For control of this type of attack, certainly the pH of the cooling tower system should be controlled, preferably close to the natural environmental pH of the cooling tower lumber.

Another source of delignification is the use of chlorine in cooling tower systems for microbiological control. Because the lignin is subject to oxidation by strong oxidizing agents such as chlorine, deterioration from this cause can be quite rapid and serious. Several investigators have reported that chlorine is removed in the cooling tower system not merely by evaporation to the air as it is passed over the tower, but also by reaction with the cooling tower lumber. This occurs even at the low concentrations of chlorine that are normally used for microbiological control, even as low as a half a part per million. At higher concentrations of chlorine, 5 ppm and above, the attack of the cooling tower lumber is much more rapid and the wood in structures can be weakened considerably in a very short period of time.

In addition to delignification, the cooling tower lumber can also be deteriorated by very low pH's as a result of over-dosage of acid or other acidic materials in the system. With this type of attack, the surface of the wood is broken down and long reddish-brown fibers result.

Although deterioration of cooling tower lumber is serious in itself, often it is combined with microbiological deterioration. Normally, we would consider that chemical deterioration of the lumber precedes microbiological deterioration, in that the cooling tower lumber initially is resistant to microbiological attack, but loses this natural resistance as the toxic extractives are removed from the lumber by leaching and other types of chemical attack. Thus, it is not sufficient to say that the wood has been subject to microbiological attack, but we must also remember that some sort of chemical attack, which has resulted in the loss of the natural resistance of the cooling tower lumber, has preceded this infection with organisms.

The deterioration of cooling tower lumber from a microbiological standpoint, can be a surface type of attack or it may be an internal type of attack. Either of these types can be extremely serious, however, the internal type of attack is perhaps the most serious in that it takes place unnoticed and the result of the attack appears only when the cooling tower lumber has lost its strength completely and the tower has collapsed.

The microbiological attack is generally attributed to certain fungi, which have the ability to utilize the cellulose constituents in the tower lumber as a source of carbon and destroy the cellulose portions of the lumber. This is in

34" full opening high pressure gas line valve—biggest ever built

This Grove Seal-O-Ring Gate Valve with the rugged fabricated steel body design is actuated by a hydraulic piston operating on pressure from the line.

THE WHOLE VALVE IS RIGHT HERE

When valve is full open or closed, bubble-tight seals on both sides of the gate completely isolate line pressure in the conduit. The body, serving merely as framework for operating mechanism and to prevent loss of product while gate is in motion, may be drained or vented to atmosphere when gate is open or closed. Integrity of seals can be checked any time by a tell-tale valve on the body.

60

GROVE SEAL-"O"-RING Gate Valves

GROVE VALVE and REGULATOR COMPANY • 65th & Hollis Sts., Oakland 8, California
HOUSTON 4 — 1901 Calumet St. • • • • • • • LOS ANGELES 6 — 1930 W. Olympic Blvd.

ODESSA, TEXAS • TULSA, OKLAHOMA • DENVER, COLORADO • In Western Canada: GROVE VALVE LIMITED

GROVE SEAL RING GROVE SIMPLICITY ACCURACY SAFETY

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

contrast to delignification in that the wood becomes rich in lignin due to removal or degradiation of the cellulose. Consequently, the wood does not take on the white appearance as is typical from the delignification type of attack and may actually become darker in that the residue is rich in lignin.

A class of fungus organisms known as Basiodiomycetes produce "brown rot" and the internal wood rot. The brown rot is found most commonly at points where the wood is in contact with iron fastenings or where a water that is high in iron drips onto the lumber. The brown rot usually follows a pattern of decaying the wood in a relatively small zone in an area adjacent to the source of the iron. Normally, the brown rot is found only in areas where the wood is moist, but not continuously flooded by the circulating water.

Another type of fungus attack is "white rot", which can spread quite readily throughout the cooling tower and is not necessarily found only in one specific location. The organism responsible for this type of attack also possesses the ability to remove lignin in addition to cellulose.

The surface attack is believed to be caused by fungus organisms such as Ascomycetes, although this has not been completely proved. The surface type of fungus deterioration generally will exhibit certain characteristics and changes that can help to serve in the identification of this type of attack. The wood may become darker in color due to the removal of cellulose, with the lignin remaining, although this may not be true in all cases. The fungus-attached wood may show a checking across the grain on the surface of the wood. The surface of the wood may become soft, from which the term "soft rot" is derived. Also, pieces of fungus-attacked wood when broken will not splinter like sound wood, but rather break across the grain almost as if cut by a saw.

The attacked lumber will also exhibit a great decrease in density, that is, it will be very light in weight.

The internal type of attack is the result of wood-destroying fungus that penetrates the wood and produce decay beneath the surface. This type of attack is extremely serious in that it is not apparent until appreciable damage has been done and the structural strength of the cooling tower lumber is affected seriously.

The internal type of attack is normally present only in those areas of the cooling tower system where the wood is moist, but not thoroughly washed by the circulating water. Also, the warmer areas of the cooling tower are more prone to this type of attack. Typical of areas where this attack has been noticed are in the mist eliminator sections and other areas above the water distribution system in the top of the tower. These areas provide the optimum conditions for the growth of the wood rot organisms in that it is moist and warm. Fig. 1 shows a typical example of this type of wood deterioration.

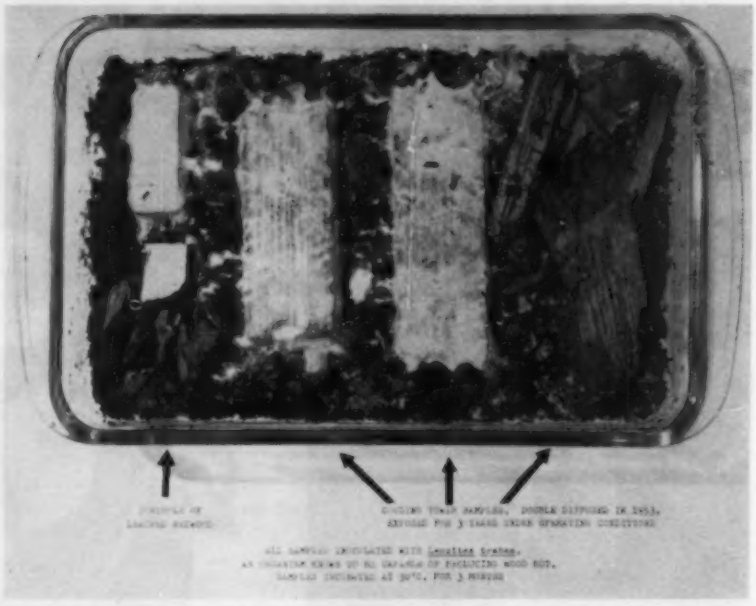


FIG. 2. **Samples of cooling tower wood** removed from tower 3 years after double diffusion. Inoculated in laboratory with wood rot organism, *Lenzites trabea*. All samples, including controls, show heavy growth of organism on wood with complete deterioration of lumber.

How to Control Deterioration

For control of cooling tower lumber deterioration there have been several methods proposed and tried in actual operating conditions. These methods can be grouped into two classifications, namely, (1) those that deal with the pretreatment of cooling tower lumber prior to the installation of the cooling tower system, and (2) those that deal with treatment of the cooling tower lumber after the tower has been in operation for a number of years and subject to the possible microbiological and chemical attack.

Generally speaking, the pretreatment of cooling tower lumber has not been generally accepted in that the economic considerations have been adverse. There are several methods of pretreating the lumber, which consist of impregnating the lumber with creosote, phenolic materials and other toxic salts, such as copper salts. Some leaching of the pretreatment chemicals and the natural preservatives in lumber by the cooling water occurs, which can result in the gradual removal of the preservatives in the lumber during the first few years of operation. If the pretreatment can be held in the lumber so that it is not removed by leaching in the first few years, then the method of approach can

DOUBLE DIFFUSION

($CuSO_4$ or $ZnSO_4$ + $Na_2Cr_2O_7$)

ADVANTAGES	DISADVANTAGES
1. EFFECTIVE – WILL PREVENT ROT.	1. EFFECTIVENESS MAY BE LOST IN ONLY 2–3 YEARS.
2. SINGLE APPLICATION.	2. MAY NOT BE ECONOMICAL IF EFFECTIVENESS IS SHORT LIVED.
3. PROVIDES FUNGISTATIC SURFACE ON WOOD.	3. TOWER TAKEN OUT OF SERVICE FOR TREATMENT.
	4. TREATMENT CHEMICALS MAY CAUSE CORROSION AND FOULING IN COOLING SYSTEM.
	5. DOES NOT CONTROL ORGANISMS THROUGHOUT THE SYSTEM. OTHER TREATMENTS REQUIRED.
	6. SPECIAL EQUIPMENT AND TECHNIQUE FOR APPLYING.
	7. POSSIBLE WASTE DISPOSAL PROBLEM.

FIG. 3. **Analysis of double diffusion** method for controlling microbiological attack of cooling tower lumber.

MICROBIOLOGICAL CONTROL PROGRAM
(SPECIFIC SLIMICIDES AND FUNGICIDES)

ADVANTAGES	DISADVANTAGES
1. EFFECTIVE – WILL PREVENT ROT.	1. REPEATED APPLICATIONS NECESSARY.
2. ECONOMICAL PARTICULARLY CONSIDERING OTHER BENEFITS.	2. POSSIBLE WASTE DISPOSAL PROBLEM.
3. TREATMENT APPLIED WITH SYSTEM IN OPERATION.	
4. NON-CORROSIVE AND NON-FOULING IN SYSTEM.	
5. PROVIDES FUNGISTATIC SURFACE ON WOOD.	
6. CONTROLS ORGANISMS ON WOOD AND THROUGHOUT THE SYSTEM.	
7. IMPROVES EFFECTIVENESS OF SCALE AND CORROSION PREVENTION PROGRAM.	
8. REPEATED APPLICATIONS EXTEND PROTECTION.	
9. EASY TO APPLY.	

FIG. 4. **Analysis of microbiological** control program method for controlling microbiological attack of cooling tower lumber.

offer economic extension of tower lumber life.

The other approach to the problem has been to treat the lumber after it has been subject to the deteriorating conditions of cooling tower operation. There have been several methods tried, which include treatment with copper or zinc chromate solution, or the selected fungicides used in a microbiological control program.

The so-called "Double Diffusion" method is one approach to treatment of the lumber for prevention of wood deterioration. This program consists of circulating or spraying a concentrated solution of $CuSo_4$ or $ZnSO_4$ over the tower lumber to penetrate the lumber with the Cu or Zn salt. Following this, a second concentrated solution of $Na_2Cr_2O_7$ is circulated, which also diffuses into the lumber where it reacts with the Cu or Zn to form an insoluble salt. The basis of the program is that the insoluble salt is toxic to the organisms and will resist leaching from the lumber, thereby providing a fungistatic wood surface.

In evaluating or analyzing this approach, we should also consider the side effects of this treatment in the cooling tower system. High concentrations of copper are extremely corrosive and, if allowed to enter the system piping, serious corrosion can result. On the other hand, if zinc is used, it may deposit out if allowed to enter the system in high concentrations. Chromate solutions pose a handling and waste disposal problem if there are strict controls by the state or federal agencies.

Even if the system is closed off before double diffusing the tower, there is some hazard involved when first putting the tower in operation due to heavy leaching of excess solution from the surface of the wood. This action is similar to starting up a new tower and the color throw which appears, or if pretreatment of wood by other means is practiced.

The double diffusion method, however, does result in penetration of the lumber with toxic salts that protect the lumber against fungus organisms. Whether this approach is the complete answer to wood deterioration has not been fully evaluated. Certainly, part of this evaluation includes the length of time over which protection is provided

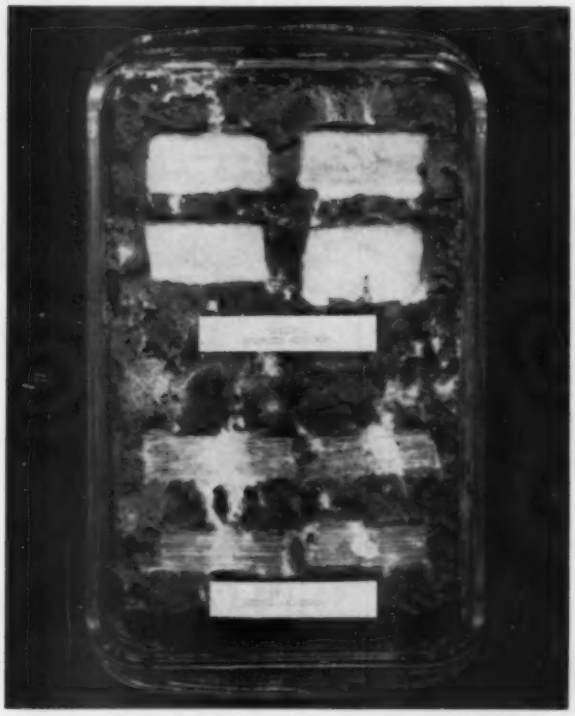


FIG. 5. **Laboratory control blocks** inoculated with fungus organism obtained from cooling tower system. The test indicates these organisms will not deteriorate wood that is susceptible to fungus deterioration.

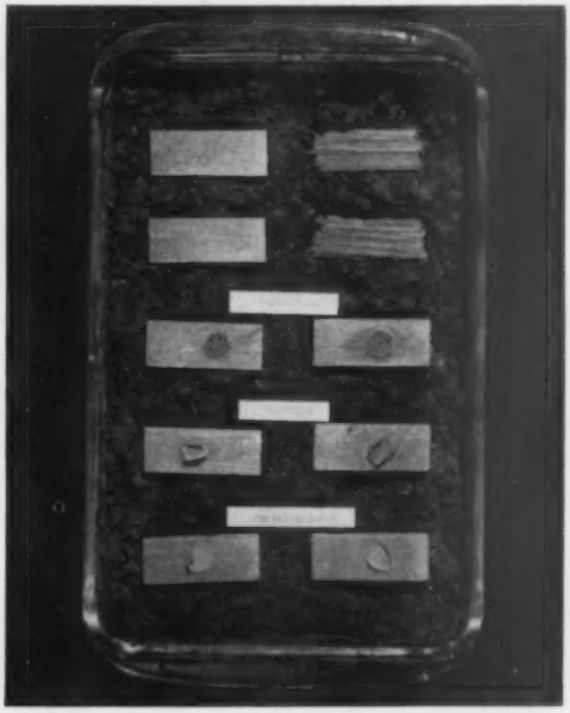
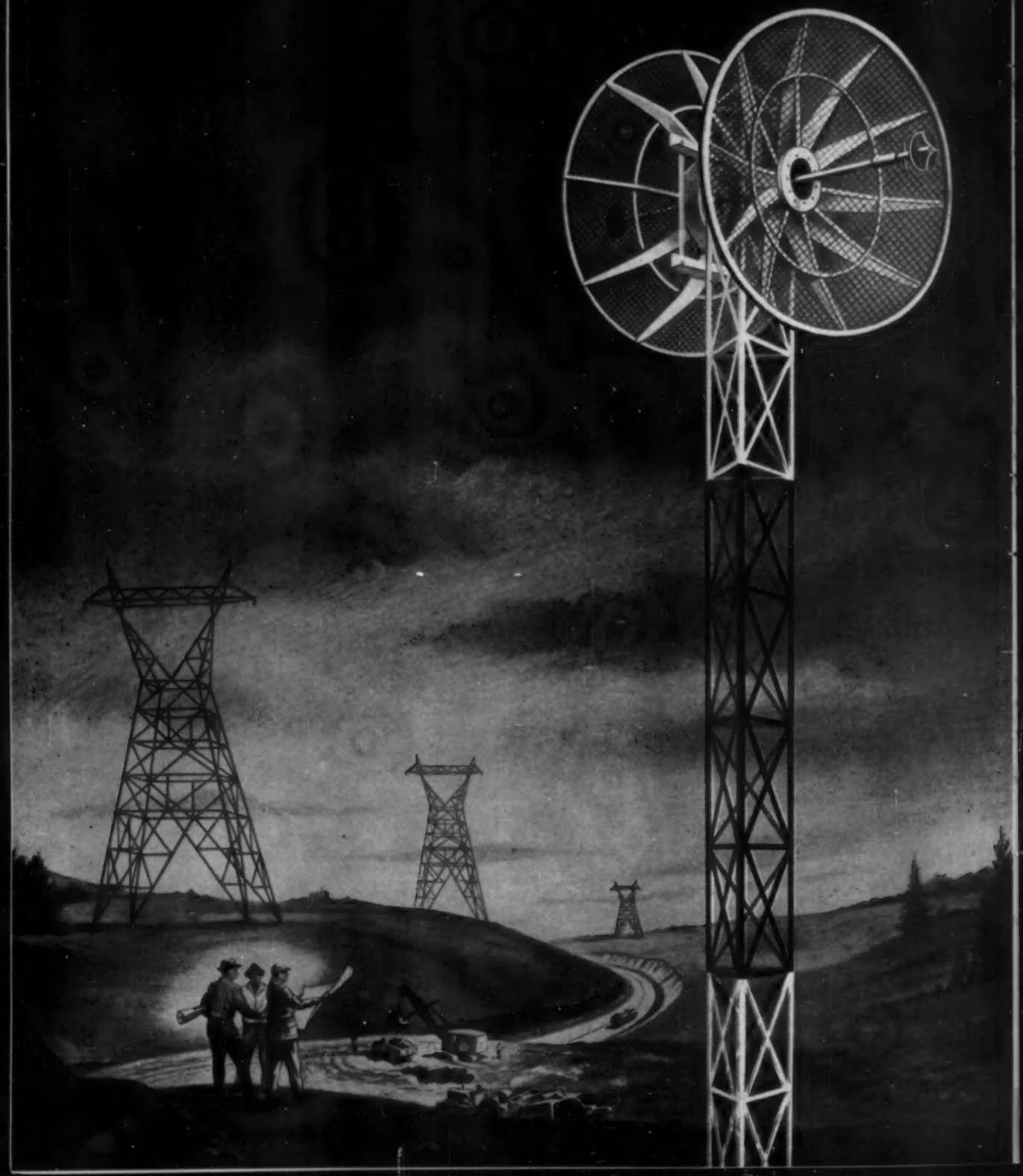


FIG. 6. **Samples of cooling tower lumber** and controls inoculated with *Lenzites trabea*. Controls show heavy growth of organisms and are completely rotted. Samples from tower contain sufficient resistance to organism to prevent deterioration of samples.

Dependable RCA



Microwave

KEEPS UTILITIES ON THE BEAM

In a tremendous surge of expansion, electric utilities are putting up new installations essential to the national economy, right across the nation.

RCA Microwave is providing these utilities with dependable communications systems, easily expandable, capable of handling every vital communication function including voice, teletype, telemetering, supervisory control, load control, relaying and transfer trip, facsimile, remote control, operation of mobile radio and others.

Through the use of microwave, voice or data intelligence reaches every part of the territory served and the whole system can be under the dispatcher's immediate control.

All this is accomplished with speed, efficiency, reliability and economy compatible with and, in most cases, superior to that provided by any other means—without high maintenance costs, expensive right-of-way problems, or vulnerability to weather vagaries.

ON PIPELINES—In the petroleum and natural gas industries where pipelines knife across the country, RCA Microwave systems link dispatching and control points with pumping stations and unattended remotely operated booster stations. Pipeline capacity is increased and operating costs are cut. VHF control channels allow immediate contact with maintenance personnel.

ON TURNPIKES—On the new cross-country superhighways RCA Microwave provides circuits for voice, facsimile, teletype, VHF control, traffic information and business machine communications . . . gives operating personnel complete control of the road, greater safety and service to driver patrons around the clock, in fair weather or foul.

RCA MICROWAVE provides the most advanced engineering features. Provision for the easy addition of future channels makes it the least expensive form of communication per channel mile. Equipment uses easy-to-service, familiar circuits and readily available tubes. Single sideband suppressed-carrier frequency division multiplex is used exclusively to meet high standards of dependability and quality of transmission. Frequency control for the system is concentrated at the terminal stations. And only *two* frequencies are usually required. Furthermore, RCA provides the nation-wide service of the RCA Service Company to keep your system operating at its peak.

RCA Microwave Representatives, with years of microwave experience, will be glad to answer any questions and to assist in planning your installation. Mail coupon for further particulars.

RCA MICROWAVE is easily interconnected with mobile radio installations as well as existing telephone lines and switchboards. Field maintenance crews, no matter how remotely located, can be contacted from any station or office. Instant communication in the field means hours per day saved in parking, backtracking and preventing costly delays.

PERFORMANCE PROVED IN MORE THAN A MILLION CHANNEL MILES OF OPERATING SYSTEMS THROUGHOUT THE WORLD

RCA MICROWAVE

POINT-TO-POINT COMMUNICATION

RADIO CORPORATION OF AMERICA

Communications Products

Camden, N. J.

Radio Corporation of America
Communications Products, Dept. J-127
Building 15-1, Camden, N.J.

☐ Please send me latest literature on RCA Microwave.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

☐ Have RCA representative get in touch with me.

— one year, two years, or three years.

We have had an opportunity to evaluate one application of the double diffusion treatment that was applied in a refinery cooling tower three years ago (1953). Tests on the wood immediately after double diffusion indicated the wood could not be rotted by known wood rot organisms. Tests three years later showed that samples of the tower lumber could be rotted in the laboratory by an organism that is known to be a wood rot organism. (Fig. 2) We have no indication that this tower is inoculated with wood rot organisms, however, the tests do indicate that should these organisms enter the system, the wood will support their growth and become deteriorated.

In this one particular case, the double diffusion treatment provided protection to the tower initially. Some time in the first three years this protection disappeared; perhaps the end of the first or second year, or perhaps the third year. The treatment program on this system has then to be evaluated on a cost basis for protection to the tower for no more than three years.

In other systems, the double diffusion method may provide protection for a shorter period of time or possibly a longer period of time. Time and tests will tell us. Fig. 3 provides an analysis of this approach to cooling tower lumber deterioration control.

The other approach to the problem of controlling microbiological attack of the lumber is the use of an effective microbiological control program, which includes the use of materials that are specific for fungus organisms, including those that produce the wood rot type of attack. The appearance of slime or fungus in the tower indicates that the microbiological control is not being obtained and conditions are also present under which the wood-destroying fungus organisms can thrive. Control of the microbiological activity in the system also means control of those fungus organisms that are capable of producing the microbiological attack.

The treatment of the cooling tower water may consist of the use of several types of slimicides. These materials may be used in conjunction with chlorine or may be used in a program that completely avoids the use of chlorine in that chlorine may be contributing to the deterioration of the lumber.

The use of an effective microbiological control program is a different approach to the problem as compared to double diffusion. The application of microbiological control chemicals is not just a single treatment, but rather is applied regularly and frequently at dosages sufficient to control the microbiological activity. This approach is aimed not only at providing a fungistatic wood surface through adsorption of the chemical onto the wood, but also at direct control of the organisms throughout the system. With this approach it is necessary to apply the treatment regularly at intervals of one or two months, depending on the severity of the problem, as the system is being continually inoculated with fungus organisms in the passage of air through the tower. Maintaining surfaces that are free from microbiological build-up and resistant to fungus attack through regular and frequent application of control treatment is an economic and effective method of controlling microbiological attack of the lumber.

In those areas of the tower where complete washing of the wood is not obtained, it may be necessary that the materials which are particularly specific for control of the fungus organisms be sprayed in these areas to cover the surfaces as completely as possible at regular and frequent intervals. Fig. 4 analyzes the microbiological control program for wood deterioration control.

A Test Procedure

Recently, our laboratories have developed a test program that has been extremely useful in evaluating cooling tower lumber samples for the possibility of occurrence of wood rot type of attack. The wood rot organism cannot be identified normally under the standard procedures and we have adopted a test that is functional in nature and enables us to actually determine whether organisms taken from cooling tower wood samples can produce decay, and whether the samples of cooling tower lumber submitted will support fungus growth and be deteriorated.

The test procedure consists of culturing species of organisms, which are isolated from the sample submitted, and taking these cultures and inoculating cooling tower lumber blocks that have been sterilized and leached free of their protective organic matter (the extractives). These inoculated blocks are then incubated for three months, at the end of which time the organisms either will have attacked the wood or will not have produced any visible effect on the wooden blocks. (Fig. 5).

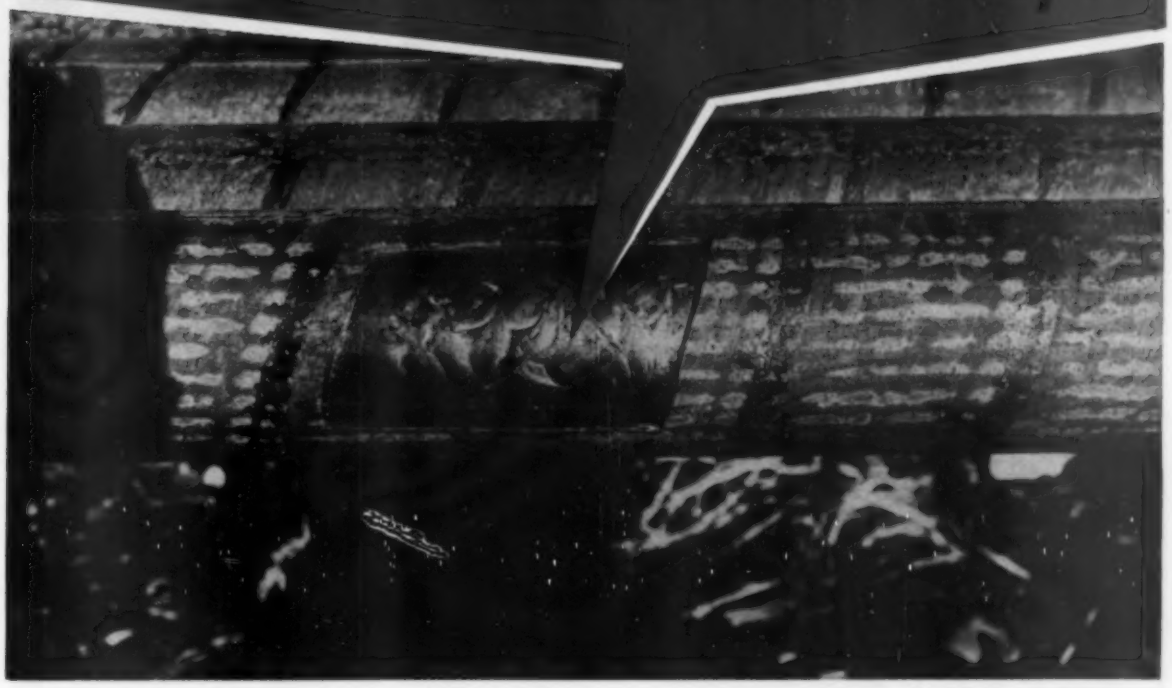
In conjunction with this part of the test, we also take a sample of the actual cooling tower lumber as it is received, sterilize it, and then inoculate the lumber with a culture of a known wood rot organism, *Lenzites trabea*. This is also incubated for three months and at this time the sample is evaluated to see whether the lumber has decayed by growth of this organism. We feel this is an important part of the evaluation in that, even though wood rot organisms may not be present in the system, the test indicates whether the wood is susceptible to attack by the wood rot organisms should the system become inoculated. (Fig. 6).

Over the past two years, we have found this test to be very valuable and an effective method of evaluating the possibility of attack. In the laboratory, we have been able to correlate results with those in the field and have been able to rot wood with organisms from samples of wood taken in the field and/or to rot wood samples sent into the laboratory by the field with cultures of known wood rot organisms. On the basis of this evaluation, we have then been able to recommend an effective cooling water treatment program that provides for control of the microbiological attack, in addition to control of the chemical attack of the cooling tower lumber by the mineral content of the water.

In summary, deterioration of cooling tower wood is a serious problem facing cooling tower operators; however, there are methods that have been used successfully for its control. The control program certainly should include the utilization of an effective scale and corrosion prevention treatment, which can be used with a neutral or slightly acid pH range. Avoiding or alleviating the chemical attack of tower lumber allows the wood to exert its natural resistance to microbiological attack. Once the toxic extractives have been removed, the wood is then vulnerable to attack. A treatment program should be selected that will control the microbiological attack on the wood, taking into consideration also the effect of the treatment program on other parts of the system.

1. Baechler, R. H., and C. Audrey Richards, "Deterioration of Wood in Cooling Towers," *ASME*, Atlanta, Ga., April 2-5, 1951.
2. Baechler, R. H., "Wood in Chemical Engineering Construction," Forest Products Research Society, May 5-7, 1954.
3. Baker, D. R., "Controlling Deterioration of Cooling Tower Lumber."
4. Baker, D. R., "Protecting Cooling Tower Lumber by the MarTreat Process."
5. Baker, D. R., "Recent Developments in Wood Deterioration of Cooling Tower Lumber," 1951 Midwest Power Conference, April, 1951.
6. Baker, D. R., "Studies Relative to Protection of Cooling Tower Lumber."
7. Baker, D. R., "Wood Deterioration in Cooling Towers," *ASME*, Dallas, Texas, April, 1950.
8. Comeaux, Roy V., "Deterioration of Redwood Cooling Towers," *API*, May 12, 1953.
9. Fluor Corporation, The, "Report on Research Relative to Delignification of Cooling Tower Lumber."
10. Hill, J. C., "The Effect of Circulating Water on Wood in Cooling Towers," Thirteenth Annual Water Conference, Pittsburgh, Pa., October 21, 1952.
11. Stewart, C. R., "Protection of Cooling Towers Against Chemical and Biological Attack," Southeastern Electric Exchange, September 24, 1954, Birmingham, Alabama.
12. Wise, R. S., "Bacteria Growths and Their Control," Thirteenth Annual Water Conference, Symposium on Cooling Towers, Pittsburgh, Pa., October, 1952.
13. Cooling Tower Wood Maintenance Study, Interim Reports A through G, 1950.
14. Institute of Paper Chemistry, Appleton, Wis., "Study of Deteriorated Redwood Specimens from Cooling Towers," Progress Report 3, Project 1561 to California Redwood Association, November, 1952. ★ ★

Will Your Pipeline Look This Good 20 Years from today?



Here's Proof that COAL TAR Coatings Last Far Longer, Cost Far Less in the Long Run!

THIS pipeline was laid many years ago. But when it was unearthed for inspection, it showed no sign of failure or deterioration—thanks to its coal tar coating, *the most dependable material ever developed for commercial pipeline protection.*

Other materials come and go, but only coal tar coatings continue to offer such concrete, *time-tested* proof of their unique ability to resist soil stress and water absorption.

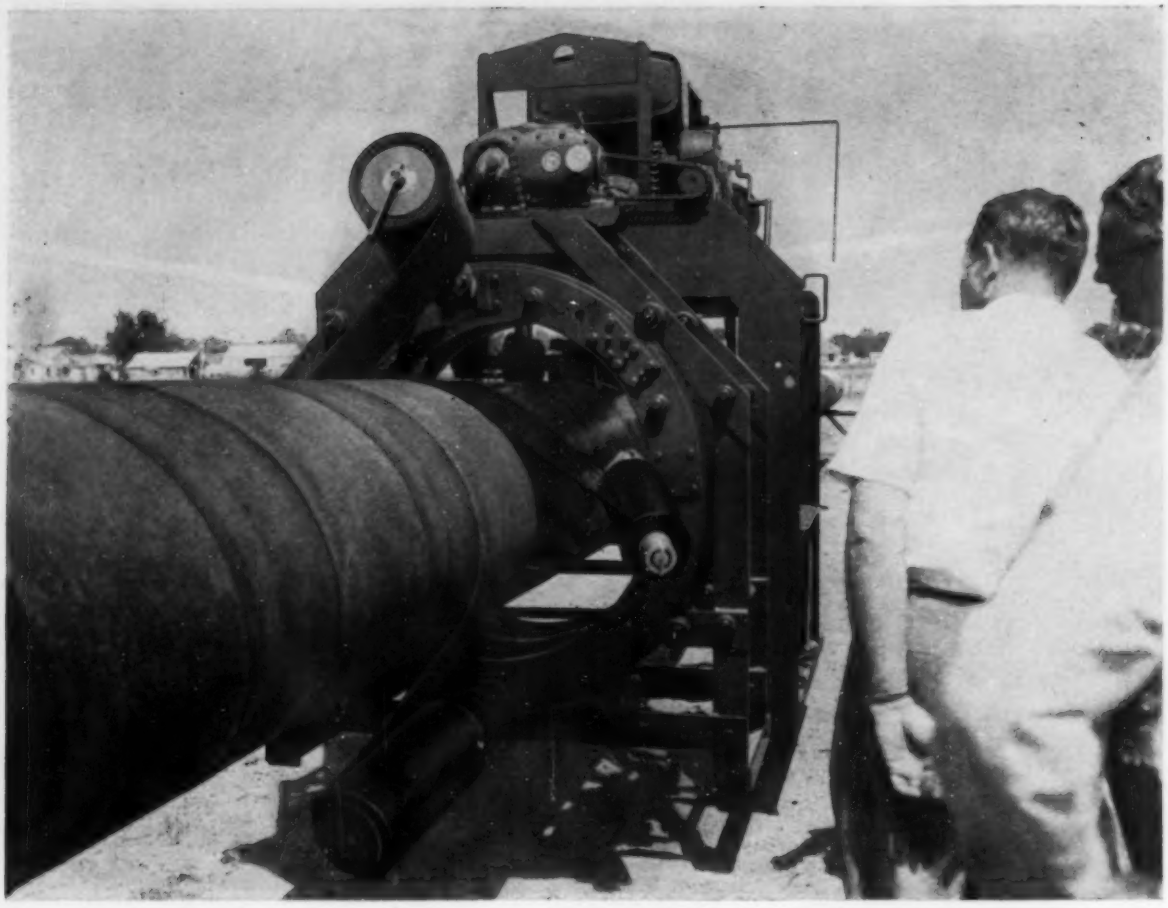
Why risk the chance of costly failures with "economy" coatings? Specify Pitt Chem *Coal Tar* Coatings and be *sure* of economical, long-lasting protection. For Pitt Chem Coal Tar Coatings are manufactured to rigid *published* specifications to give you assured protection with every drum. How can we help *you?* Send us the details of your coating problem.

PITT CHEM®TAR BASE COATINGS

- Standard Grade • Modified Grade
- Plasticized Grade • Hotline
- Cold Applied Tar Base Coatings

WBW 6015

COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON



HOW MUCH CAN YOU SAVE

if you protect your pipeline with Polyken Protective Tape Coatings?

MORE—PROBABLY A LOT MORE THAN YOU THINK.

We wouldn't want you to assume that *Polyken* Protective Tape Coatings are priced lower than all other coatings. They aren't, and may sometimes even cost a little more applied than lower quality coatings.

But here are 6 reasons why we *can* promise a substantial saving:

1. *Polyken* controlled strength—careful control in the selection and processing of raw materials;
2. Uniform thickness and quality;
3. Rugged, long-lasting protection from corrosion;
4. Application right from the roll—no heat, thinners, or solvents, no drying or clean-up time required;
5. High speed, low-labor power taping for "big inch" as well as "littlest inch" installations;
6. Lowest equipment investment and manpower costs possible.

Of course we can't figure your costs here in dollars and cents. But show us your plans—and we suspect you'll be surprised at how much you can save on dependable protection.

Let's talk it over now. Write, wire, or phone *Polyken*, 309 W. Jackson Blvd., Dept. PE-I, Chicago 6, Illinois, RAndolph 6-4250.

Complete catalog, Sweet's Industrial Construction File, Sec. 11c Ke

Polyken®

CONTROLLED STRENGTH

PROTECTIVE COATINGS

THE KENDALL COMPANY, POLYKEN SALES DIVISION

Cathodic Protection Interference Problems

How to Solve Them

Francis W. Ringer
Consulting Engineer
Narberth, Pennsylvania

ONE of the most important aspects involved in the engineering of a cathodic protection installation on a subsurface metallic structure is that of determining the extent of possible interference on neighboring structures which are not primarily considered a part of the cathodic protection system. It is the duty of the designing engineer to give thought to the possibility of his application of cathodic protection creating interference on neighboring structures because he can be held responsible for damage caused thereby. The engineering of a given project can easily be made more complicated when remedial measures are required to eliminate interference; nevertheless, the job is not finished until these measures are taken. It behooves the engineer to apply the golden rule.

There are several methods of solving interference problems and excellent papers concerning cathodic protection and interference problems have been written.[1, 2] It is the purpose of this article to explain the use of the network method in solving these problems.

The Network Method

The network method was originated approximately twenty years ago by the late Dr. J. M. Pearson, as a result of his studies in connection with the solution of electrolysis problems created by stray currents on underground pipe lines and railway cables.[3] Many years of experience obtained from the application of Dr. Pearson's method by a large number of engineers has shown that the network method is well adapted to the solution of cathodic protection and interference problems as well as those due to stray currents.

[1] J. M. Pearson. Measurements of Cathodic Polarization and of Problems of Interference on Underground Structures, Bureau of Standards Corrosion Conference, 1943.
[2] A. V. Smith. Cathodic Protection Interference, American Gas Association Distribution Conference, 1943.
[3] J. M. Pearson. Electrical Instruments and Measurements in Solution of Electrolysis Problems, Bureau of Standards Corrosion Conference, 1937.

Fundamental Bases

The derivation of the network method is based upon three fundamentals: First, neglecting the effect of polarization, the resistance to earth of a buried pipe line or cable remains practically constant with respect to time. Except in the case of shallowly buried systems during extended periods of drought, many tests over periods of several years have shown that the resistance to earth of a given line or cable varies only within narrow limits which can be tolerated from an engineering standpoint.

The significance of this is that the internal resistance (resistance through earth) between two or more neighboring underground structures is constant. A commonly observed manifestation of this is, in general, the constant relationship between voltage and current output of a cathodic protection rectifier before appreciable deterioration of the ground bed sets in.

Second, since only direct currents are involved in corrosion and cathodic protection circuits, the relationship between voltage and currents at any point in an underground electrical network created by neighboring buried pipes and cables, is linear or directly proportional. In other words, the use of Ohm's Law is perfectly valid in studying conditions on an underground system.

The significance of this is that if one ampere of cathodic protection current will result in a change of .1-volt between structure and earth at any given place, increasing or decreasing this current by a certain amount will cause a proportional increase or decrease in structure to earth voltage at the same place. The relationship between voltage change between structure and environment at any given point, and current flow between structure and environment causing the change, is fixed in accordance with Ohm's Law.

This is true regardless of whether the voltage change is positive or negative, and whether the source of current is connected to the structure of interest to provide cathodic protection, or is connected to a foreign structure so that interference current flows on the structure of interest. Likewise, the voltage change between neighboring, but unconnected, structures holds a fixed relationship with current output from a cathodic protection rectifier which is connected to one of the structures involved, and which causes a change in voltage between structures. Again, if the structures happen to be electrically connected, the current flow between these structures holds a fixed relationship with the rectifier current causing this flow.

Third, according to the concept of superposition of currents and voltages, if an interference current, or current causing corrosion, is flowing along a pipe line, and a cathodic protection or bond current is caused to flow in order to produce a counterbalancing effect, the manifestation of each of these currents separately (such as IR drops along the pipe line or cable, voltages between pipe line or cable and earth, etc.) is the same as if that current existed alone. Thus the total effect of the two currents together is the algebraic sum of each.

If one or the other of the currents can be interrupted or caused to vary in a measurable amount, the effect of that

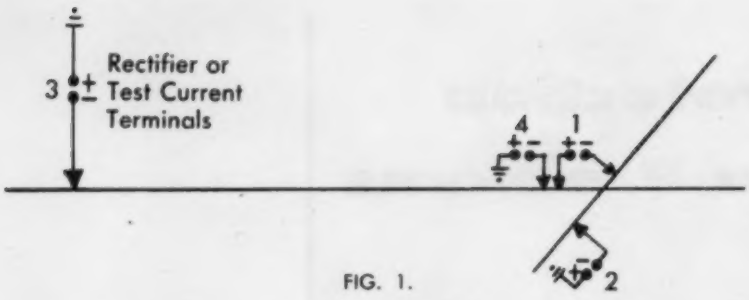


FIG. 1.

CORROSION CONTROL SURVEY

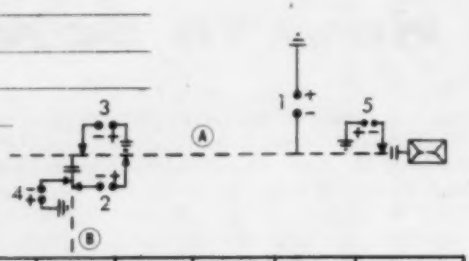
COMPANY_____

LOCATION_____

_____

TESTERS_____

DATE_____



Open ckt. Voltage between pipelines (E_2) = 3 Volts

2:41 p.m.	2:41 p.m.	2:46 p.m.	2:46 p.m.	2:53 p.m.	2:53 p.m.	3:51 p.m.	3:51 p.m.	
I_2 #2 100 A.	Vg_1 #1 VTVM 10 V.	I_2 #2 100 A.	Vg_1 #1 VTVM 10 V.	I_2 #2 100 A.	E_2 #1 VTVM 10 V.	I_2 #2 100 A.	Vg_1 #1 VTVM 10 V.	
+ 10.0	+ 2.74	+ 11.2	— 1.21	+ 10.8	+ 3.62	+ 15.0	— 4.08	
0	— .38	0	+ .21	0	— .22	0	— 1.87	
	+ 3.12		— 1.42		+ 3.84		— 2.21	
+ 10.9	+ 2.68	+ 10.7	— 1.21	+ 10.8	+ 3.65	+ 15.0	— 4.08	
0	— .42	0	+ .10	0	— .21	0	— 1.78	
	3.10		— 1.31		3.86		— 2.30	
+ 10.8	+ 2.72	+ 10.2	— 1.22	+ 10.3	+ 3.73	+ 13.5	— 3.10	
0	— .42	0	+ .09	0	+ .08	0	— 1.12	
	3.14		— 1.31		3.81		— 1.98	
+ 10.8	+ 2.73	+ 10.2	— 1.27	+ 10.7	+ 3.61	+ 12.0	— 2.70	
0	— .41	0	+ .03	0	— .08	0	— .97	
	3.14		— 1.30		3.69		— 1.73	
+ 11.0	+ 2.69	+ 10.4	— 1.27	+ 10.4	+ 3.69	+ 11.9	— 2.42	
0	— .51	0	+ .09	0	— .09	0	— .78	
	3.20		— 1.36		3.78		— 1.64	
+ 10.2	+ 2.89	+ 10.5	— 1.28	+ 10.9	+ 3.59	+ 12.0	— 2.02	
0	— .10	0	+ .04	0	— .38	0	— .12	
	2.99		— 1.32		3.97		— 1.90	
+ 10.4	+ 2.81	+ 9.8	— 1.21	+ 10.1	+ 3.79	+ 11.9	— 2.62	
0	— .13	0	+ .01	0	+ .21	0	— 1.02	
	2.94		— 1.22		3.58		— 1.60	
+ 11.1	+ 2.63	+ 10.2	— 1.25	+ 10.6	+ 3.65	+ 12.0	— 2.03	
0	— .58	0	+ .08	0	— .18	0	— .30	
	3.21		— 1.33		3.83		— 1.73	
+ 10.6	+ 2.82	+ 10.2	— 1.23	+ 10.3	+ 3.70	+ 13.0	— 2.27	
0	— .31	0	+ .04	0	0	0	— .28	
	3.13		— 1.27		3.70		— 1.99	
+ 10.7	+ 2.71	+ 10.2	— 1.28	+ 10.3	+ 3.70	+ 12.0	— 2.50	
0	— .39	0	+ .01	0	— .12	0	— .86	
	3.10		— 1.29		3.82		— 1.84	
106.5	31.07	103.6	—13.13	105.2	37.88	128.3	—18.72	
$R_{1,2}$=	31.07 / 106.5	$R_{2,2}$=	—13.13 / 103.6	$R_{2,1}$=	37.88 / 105.2	$R_{2,2}$=	—18.72 / 128.3	
=	+ .292	=	— .127	=	.360	=	— .146	

FIG. 2.

current alone can be determined by measuring the change in total effect simultaneously with current change. In words of the late A. V. Smith, one current is painted red in order that it may be distinguished from any others flowing in the same circuit.

These characteristics of the electrical network created by neighboring underground structures provide the corrosion engineer with a very convenient method of solving problems relating to cathodic protection and associated interference on an engineering basis rather than upon cut-and-try methods. Once a given criterion for protection has been adopted, the current magnitude needed to protect a given line, or the amount of line that can be protected with a given magnitude of current can be determined; the extent of interference upon foreign structures can be determined; and data can be taken which will permit bond resistance requirements to be calculated.

Test Procedure

The fixed relationships between currents and voltages, called *network constants*, at various points in the underground network are easily measured in the field; these constants are then used algebraically to arrive at the particular solution desired. The simplest example of this would be the problem of determining how much rectifier current would be required to change the structure to soil voltage on a coated pipe line to the commonly employed value of .85-v at a point 10 miles from the rectifier. If the residual, or natural, pipe to soil voltage is .6-v, this means that sufficient rectifier current must flow to cause a change in pipe to soil voltage of .25-v at the place 10 miles distance.

The test procedure would consist of installing a temporary test anode or ground bed at the place where the permanent ground bed is to be installed, and connecting a test current battery or generator between the pipe line and ground bed. This test current circuit is then alternately made and broken rhythmically, either by hand operation or by use of an automatic switch which will allow test current to flow at periodic intervals.

The test current can be of any convenient magnitude that will produce a good, readable, deflection of the meter measuring pipe to soil voltage at the ten-mile point. Simultaneous readings are then taken of test current, and change in pipe to soil voltage caused by the test current in sufficient number to provide a valid average.

The pipe-to-soil voltage change in volts is then divided by the test current in amperes to produce the network constant. In accordance with Ohm's Law the unit of this constant can be called

Elementary Dr. Watson!
The clue to Gaso's leadership in its field lies in the experience of those who use GASO Pumps . . . a record of performance, operating economy and durability that has kept GASO Pumps first in their field for more than 40 years.

GASO SERIES 1700—Admirably suited to pumping large capacities at high pressures. Embody all the recognized Gaso features. Crank case fully enclosed. Working parts operate in oil bath.

GASO PUMP & BURNER MFG. CO.
902 East First Street, Tulsa, Oklahoma
EXPORT OFFICE: **149 Broadway, New York, N. Y.**

FIRST IN THEIR FIELD

GASO PUMPS
for every oil industry need

DISTRIBUTORS

W. L. SOMNER COMPANY, Shreveport, Louisiana • Odessa, Texas • Tinsley, Mississippi • Brookhaven, Mississippi
POWER PUMPS, INC., Long Beach, California
PEDDLERS, INC., Houston, Texas
PUMP ENGINEERING CO., Wichita Falls, Texas
LUFKIN FOUNDRY & MACHINE CO., Casper, Wyoming
LUFKIN MACHINE CO., Ltd., Edmonton, Alberta

GET GASO DEPENDABILITY IN WATER FLOODING, TOO

how to
CUT CORROSION LOSSES
a report by Koppers Company, Inc.

C. U. Pittman
Supervisor Technical Services

Good surface preparation is basic to the life and effectiveness of protective coatings. Without it, the coating cannot bond properly and may fail to prevent future corrosion.

The surface preparation method selected depends on the type of surface, the degree of corrosion, contaminants present, the desired life of the coating and the physical accessibility of the surfaces to be coated.

* * *

To remove all traces of grease or oil, vapor degreasing or solvent cleaning is necessary *before* mechanical surface preparation. Acid cleaning or pickling to remove rust and mill scale is fast and usually low in cost. After treatment, the acid should be neutralized immediately.

Hand cleaning is recommended only on small jobs, or where areas are not easily accessible. The main problem in using chisels and pointed scrapers is to avoid high ridges which cause thin spots or holidays in the coating. Power brushing and scraping are two of the more common methods of preparing surfaces. For removing rust, they are both quite effective and, usually, reasonable in cost. We have found, though, that power brushing frequently polishes surfaces too much.

Flame cleaning is a good way to remove old coatings and to heat surfaces prior to applying a thermoplastic coating. Flame cleaners are also very good for drying damp surfaces. By creating thermal shock, flamers are an effective—though slow—way to remove mill scale. Surfaces should always be wire-brushed after flame cleaning.

Blast cleaning with sand or grit has proved to be the best way to remove incrustation, rust and mill scale, and is more economical than is generally realized. Blasting is fast on even the most irregular objects. Good practice leaves the surface free of high peaks, but with shallow valleys that make good "anchors" for the coating. Care should be exercised that the air used in blasting is free of oil. Coatings should be applied immediately after blasting or the surface should be primed quickly with WP-1, two compartment type wash primer. WP-1 should also be applied if the cleaned surface cannot be completely dried.

* * *

Concrete and masonry surfaces are prepared best by hand cleaning, power brushing or chemical cleaning. Brushed surfaces should be blown clean with oil-free air, and chemical cleaners should always be neutralized, or removed by flushing, immediately. Patching and repair work should be prepared in the same manner as the original surface.

* * *

The extra care and investment in thorough surface preparation always pay dividends in effective, long-lasting corrosion protection.

Your corrosion problems are our business. If you have any questions on which you'd like assistance, write: Koppers Company, Inc., 1301 Koppers Building, Dept. 105J, Pittsburgh 19, Pa. District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh and Woodward, Ala. In Canada: Koppers Products, Ltd., Toronto, Ontario and Edmonton, Alberta.

KOPPERS

BITUMASTIC
REG. U. S. PAT. OFF.
COATINGS AND ENAMELS

ohms since it is a ratio of volts to amperes, but it is more realistically called *volts per ampere* because the aspect of *ohms* has no practicable significance except from a mathematical standpoint.

In other words, this constant is the voltage change that would be produced by one ampere of test current. In order to determine the magnitude of current required to produce a given voltage change, this required change is divided by the network constant. For example from our original problem: If the required voltage change is .25-v, and it is found that 20 amp of test current changes the pipe to soil voltage .4-v, thus producing a network constant of .02-v per ampere, the magnitude of rectifier current needed to produce a pipe-to-soil voltage of .85 at the point 10 miles distant would be

$$\frac{.25}{.02} = 12.5 \text{ amperes.}$$

Effect of Polarization

It was implied at the beginning of this discussion that the derivation of the network method disregards the effect due to polarization. This is because the effect of polarization on a sub-surface structure is to increase the resistance between structure and earth; but since polarization is a function of current magnitude, time, and environmental characteristics, its effect cannot be predetermined by simple test methods.

The use of network methods and analyses, however, is not thereby rendered invalid for the reason that changes due to polarization are generally relatively small, and are always of such an effect so as to provide a safety factor. Intelligent observation by the corrosion engineer under a given set of conditions will provide experience whereby valid predictions can be made for future comparable conditions.

Interference Problem

The method just shown for the determination of cathodic protection current requirement can also be employed for the solution of interference problems. First things should come first, however, and in connection with interference this involves the location of the rectifier ground bed with respect to the configuration of the structures involved, when it is found that a cathodic protection installation will create interference on neighboring structures.

In other words, the location of the ground bed with reference to neighboring structures which are not to be made a part of the cathodic protection system is the first step to be considered if interference on the foreign structures is to be at a minimum.

Dig 16 to 26 inches wide . . . . . 5¾ feet deep

. . . . . with Parsons 150 Trenchliner®

Precision grading accuracy is important on pipeline work — and you get just that with this heavy-duty 150 Trenchliner. Hydraulic ram on vertical mast raises and lowers the digging wheel. It gives infinite depth selections — maintains close grade tolerance in toughest digging. A separate ram tilts the mast — balances weight of wheel forward when traveling or trailer-loading.

For all its fractional-inch accuracy, Parsons 150 has plenty of speed and capacity. 30 digging speeds range from 12 inches to 25 feet per minute, at widths from 16 to 26 inches — depths to 5¾ feet. Dual-purpose friction clutch drives the digging wheel, and automatically protects against shock loads. Heavy cast-steel buckets with "Tap-In" teeth are interchangeable with gumbo buckets. Shiftable, reversible conveyor discharges spoil to either side. Standard tractor crawlers have 16-inch grouser-type treads, provide plenty of sure-footed digging traction on cross-country work. Yet, ground-bearing pressure is low — only 6.3 pounds p.s.i. For power, you have a choice of standard-make gas or diesel engine.

Better check how this 150 wheel-type Trenchliner can put you miles ahead on main-line trenching, gathering-lines, and laterals. Call Parsons distributor, or send for new catalog. (Other sizes include big, ladder-type Trenchliners, full crawler mounted — and mobile, rubber-tired Parsons Trenchmobile®.)

Buckets and side-cutters on all Trenchliners are equipped with Parsons double-point "Tap-In" teeth. It takes less than a minute to reverse or replace a tooth. You just drift out the old tooth, reverse it, or tap in a new one. It's self locking, held in place by precision-fit taper. Easily inserted. There are no bolts to tighten — no edges to crimp.

Mail to: **PARSONS COMPANY, Newton, Iowa** *(Koehring Subsidiary)*

Send us: ☐ spec. sheet ☐ catalog on 150 wheel-type Trenchliner

NAME _____ TITLE _____

COMPANY _____

DIVISION _____

STREET _____

CITY, STATE _____

Anode Location

When a buried anode is connected to the positive terminal of a d-c source, the potential of the earth surrounding the anode is raised, the magnitude of increase depending upon the distance from the anode. The maximum increase of potential is in the earth immediately adjacent to the anode, and as distance from the anode increases, the rise of earth potential decreases.

This change of earth potential in the area surrounding the anode is called the *anode potential gradient*. If a metallic structure such as a buried pipe line or cable traverses this gradient, current will flow from earth to structure, and will flow along the structure away from the vicinity of the anode and from the structure back to earth at points remote from the anode.

Conversely, if an underground metallic structure is connected to the negative terminal of a d-c source, the potential of the earth surrounding the structure will be depressed, the magnitude again being an inverse function of distance from the structure. This change in earth potential is called the *cathode potential gradient*, and a pipe line or cable lying in this gradient will be subjected to current flow from remote points along the structure, which will be discharged from structure to earth in the vicinity of the cathode.

Thus, it is obvious that when a ground bed is constructed as part of a system to provide cathodic protection to an underground structure, this ground bed can cause interference current to flow on neighboring structures, the magnitude and polarity of the interference current depending upon the location of the ground bed with reference to the neighboring structures.

If these structures are influenced more by the cathode than by the anode gradient, interference current will flow from remote points along the structure toward the cathode, and discharge of this current to earth in the vicinity of the cathode can be prevented by installing a metallic connection called a bond between the foreign structures and the cathode or structure under protection.

If the foreign structures are influenced more, however, by the anode than by the cathode gradient, interferference current will flow radially or endwise to be discharged back to earth at remote points. This flow of endwise current to earth is usually difficult to prevent because the discharge areas are generally remote from the cathode or the structure under protection which precludes the use of bonding as a means of control.

When a cathodic protection system is designed, in nearly all cases the underground structures that may be affected either adversely or beneficially by the cathodic protection current are in place and cannot be moved. Therefore, the only remaining freedom left to the corrosion engineer is in the placement of the ground bed, and this should be fully considered.

Preliminary tests should be made to determine the effects upon foreign structures as well as the structure to be protected which are caused by various locations of the ground bed. These tests are not difficult to make and do not require extensive test anodes or ground beds. An excellent article which covers this situation in more detail has been written by A. V. Smith.[2] A little additional time spent and test work done in this respect can easily prevent later complications and abnormal work and expenditures.

Bond Problem

After the best site has been selected for the ground bed and it is desired to determine the value of current that will be required to flow from the foreign structure to the structure under protection through a bond connection, test data are taken. From these data, calculations can be made of bond current required to prevent interference and

AN-SPEC

COMPLETE CATHODIC PROTECTION

- COMPREHENSIVE SURVEYING
- EXPERIENCED ENGINEERING
- QUALITY MATERIALS
- CONSTRUCTION KNOW-HOW

You can expect the best results only by using the complete services and quality products of a company specializing in cathodic protection. You will get the best results when you call in AN-SPEC anode specialists. They furnish every service and highest quality anodes — complete cathodic protection.

PIPE LINE ANODE CORPORATION

P. O. BOX 996 • TULSA, OKLAHOMA

2230 Magnolia Street, Birmingham, Alabama
11525 East Colfax, Denver (Aurora), Colorado
858 Wilson Avenue, Newark, New Jersey
912 West 11th, Houston, Texas

Distributor: Crose-Curran, Ltd., Edmonton, Alberta—Phone 3-5135

ANODE SPECIALISTS
AN-SPEC

the value of bond resistance needed to produce that magnitude of current. In order to make the required tests, it is not necessary nor usually advisable to wait until the final cathodic protection system is installed. A test anode placed at the same site chosen for the permanent ground bed, and a test current source consisting of a portable d-c generator or batteries can be used.

While a convenient value of test current is being thrown on and off between the test anode and the structure to be protected, a survey is conducted along the foreign structure to determine the location of maximum exposure that must be cleared by the bond installation. This is done by reading the change in ground voltage at various points along the foreign structure caused by a given value of test current. The location of maximum exposure is the location where the foreign structure goes positive to earth by the greatest magnitude, and it is this location where test data are taken for bond calculations.

In terms of network constants, the formula for bond resistance is:

$$R = \frac{R_{2,1}}{\beta_{2,1}} = R_{1,1} \text{ ohms}$$

where

$R_{2,1}$ = Change in ground voltage on the foreign structure caused by one ampere of current between structures. This is called the ground voltage coupling.

$\beta_{2,1}$ = Ratio of ground voltage change on the foreign structure, to voltage change between the foreign structure and protected structure caused by the test current flow between the test anode and line to be protected.

$R_{1,1}$ = Internal resistance (resistance through earth) between the structures at the bond location. This is the ratio of voltage change between structures to current between structures.

It will be noted that the numbered subscripts represent the locations of numbered terminal where data are taken. The first subscript is the number of terminals where the data used for the numerator of the ratio are taken, and the second subscript is for the denominator.

For example, Fig. 1 shows a representative configuration of two pipe lines, one of which is to be cathodically protected. A bond is to be connected between the two to prevent interference on the foreign line. The numbered terminals shown represent the terminals of the meters used for making observations.

The network constant ($R_{2,1}$, for example) is obtained by reading the change in voltage at terminals 2 (Vg_2) simultaneously with currents at terminals 1 (I_1) which causes the change. The change in voltage, Vg_2, is then divided by the current, I_1, to give $R_{2,1}$ which is the voltage change at terminals 2 per ampere of current at terminals 1.

The formula given for bond resistance is derived as follows: With a meter connected at terminals 2 in Fig. 1 to measure pipe to soil voltage, it can be seen that with the rectifier in operation the reading given by the meter which will be called Vg (for ground voltage), is the algebraic sum of two parts or components, one being the voltage, called α, that would be read between pipe and reference electrode if the rectifier were shut down, and the other being the exposure value caused by interference from rectifier operation.

As direct current is involved with its linear relationships, there is a fixed relationship between the change in Vg_2 caused by interference current from the

CORRESPONDENCE SURVEY

COMPANY_____

LOCATION_____

_____

TESTERS_____

DATE_____

SEE FIGURE 2

2:41 p.m.	2:41 p.m.	2:46 p.m.	2:46 p.m.	2:53 p.m.	2:53 p.m.	3:51 p.m.	3:51 p.m.	
I_2 #2 100 A.	Vg_4 #1 VTVM 10 V.	I_2 #2 100 A.	Vg_3 #1 VTVM 10 V.	I_2 #2 100 A.	E_3 #1 VTVM 10 V.	I_2 #2 100 A.	Vg_3 #1 VTVM 10 V.	
+ 10.0	+ 2.74	+ 11.2	— 1.21	+ 10.8	+ 3.62	+ 15.0	— 4.08	
0	— .38	0	+ .21	0	— .22	0	— 1.87	
	+ 3.12		— 1.42		+ 3.84		— 2.21	
+ 10.9	+ 2.68	+ 10.7	— 1.21	+ 10.8	+ 3.65	+ 15.0	— 4.08	
0	— .42	0	+ .10	0	— .21	0	— 1.78	
	3.10		— 1.31		3.86		— 2.30	
+ 10.8	+ 2.72	+ 10.2	— 1.22	+ 10.3	+ 3.73	+ 13.5	— 3.10	
0	— .42	0	+ .09	0	+ .08	0	— 1.12	
	3.14		— 1.31		3.81		— 1.98	
+ 10.8	+ 2.73	+ 10.2	— 1.27	+ 10.7	+ 3.61	+ 12.0	— 2.70	
0	— .41	0	+ .03	0	— .08	0	— .97	
	3.14		— 1.30		3.69		— 1.73	
+ 11.0	+ 2.69	+ 10.4	— 1.27	+ 10.4	+ 3.69	+ 11.9	— 2.42	
0	— .51	0	+ .09	0	— .09	0	— .78	
	3.20		— 1.36		3.78		— 1.64	
+ 10.2	+ 2.89	+ 10.5	— 1.28	+ 10.9	+ 3.59	+ 12.0	— 2.02	
0	— .10	0	+ .04	0	— .38	0	— .12	
	2.99		— 1.32		3.97		— 1.90	
+ 10.4	+ 2.81	+ 9.8	— 1.21	+ 10.1	+ 3.79	+ 11.9	— 2.62	
0	— .13	0	+ .01	0	+ .21	0	— 1.02	
	2.94		— 1.22		3.58		— 1.60	
+ 11.1	+ 2.63	+ 10.2	— 1.25	+ 10.6	+ 3.65	+ 12.0	— 2.03	
0	— .58	0	+ .08	0	— .18	0	— .30	
	3.21		— 1.33		3.83		— 1.73	
+ 10.6	+ 2.82	+ 10.2	— 1.23	+ 10.3	+ 3.70	+ 13.0	— 2.27	
0	— .31	0	+ .04	0	0	0	— .28	
	3.13		— 1.27		3.70		— 1.99	
+ 10.7	+ 2.71	+ 10.2	— 1.28	+ 10.3	+ 3.70	+ 12.0	— 2.50	
0	— .39	0	+ .01	0	— .12	0	— .86	
	3.10		— 1.29		3.82		— 1.84	
106.5	31.07	103.6	—13.13	105.2	37.88	128.3	—18.72	
$R_{1,1}$=	31.07 / 106.5	$R_{1,1}$=	—13.13 / 103.6	$R_{1,1}$=	37.88 / 105.2	$R_{1,1}$=	—18.72 / 128.3	
=	+ .292	=	— .127	=	.360	=	— .146	

FIG. 3.

rectifier, and the change in voltage, V_1 between structures at terminals 1 due to this same rectifier current. This relationship will be called $\beta_{2,1}$ and is the percentage of the change in voltage at terminals 1 that appears as voltage change at terminals 2.

The value of β is determined by reading simultaneously the change in voltage at terminals 1, and 2, as the rectifier or test current at terminals 3 is turned on and off, and then taking the ratio $\frac{\Delta Vg_2}{\Delta V_1}$, where Δ means change.

Another method of computing β would be by taking the ratio $\frac{R_{2,3}}{R_{1,3}}$ which is voltage change at terminals 2 per ampere of test current at terminals 3 divided by the voltage change at terminals 1 per ampere of test current at terminals 3. Thus the meter measuring ground voltage at terminals 2 can be represented as $Vg_2 = \alpha_2 + \beta_{2,1} V_1$.

If a bond is now connected between lines so that bond current can flow, a third component of ground voltage is introduced which will influence the meter reading at terminals 2. Since the effect of bond current flowing from the foreign line to the protected line has the effect of providing cathodic protection to the foreign line by depressing its potential with respect to earth, it will have the opposite effect upon the foreign line from rectifier current; thus it will have opposite sign or polarity. With the test terminal polarities as shown in Fig 1, $R_{2,3}$ would be negative and $R_{2,1}$ would be positive.

With the rectifier in operation to cause interference on the foreign line, and a bond between lines in place to allow bond current to flow, the ground voltage being measured at terminals 2 can now be represented as follows:

$$Vg_2 = \alpha_2 + \beta_{2,1} V_1 + R_{2,1} I_1 \text{ volts} . \quad (1)$$

The third term, $R_{2,1} I_1$, expresses the change in ground voltage at terminals 2 caused by bond current flow between lines. $R_{2,1}$ represents the voltage change per ampere of bond current, therefore if this is multiplied by the total bond current, I_1, the product, $R_{2,1} I_1$, represents the total voltage change. Equation 1 is called the ground voltage equation.

Since the last two terms in equation 1 have opposite effects upon the foreign line, the final effect upon the line will be the same as if no interference current exists if these values are made equal in magnitude. This can be done by equating the two and solving algebraically for I_1 which is the critical value of bond current required to nullify interference effects:

$$\beta_{2,1} V_1 = R_{2,1} I_1$$

Therefore

$$I_1 = \frac{\beta_{2,1} V_1}{R_{2,1}} \text{ amperes} . \quad (2)$$

This is the value of I_1, or bond current, that is required to cancel the exposure effect due to interference. $\beta_{2,1}$ and $R_{2,1}$ are network constants which are easily determined from field test, and V_1 is the voltage change between lines caused by interference current from the rectifier; this also is determined from field test.

A good method of doing this would be to measure voltage change between lines, ΔV_1, simultaneously with rectifier current, I_3. The ratio $\frac{\Delta V_1}{I_3}$, then is the voltage change per ampere of rectifier current. When this ratio is multiplied by total rectifier current the total voltage change between lines is determined.

The next step in solving the bond problem is to determine the value of bond resistance required, with V_1 known, to pass the proper value of bond current, I_1. It is well known that when the terminals of a cell or battery are connected to some value of external resistance to allow current to flow, the magnitude of current will be the ratio of open circuit battery voltage to the sum of external resistance and internal battery resistance.

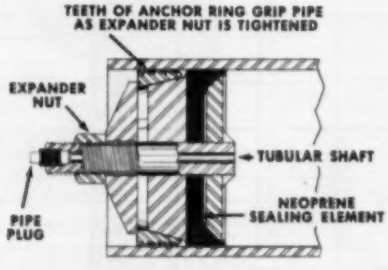
The same situation is presented by the two pipe lines which are to be bonded. Terminals 1 represent the bat-

Here's a better way...

TO PLUG PIPE ENDS TEMPORARILY

WmSON WEDGE-LOCK PIPE PLUG

In Order To:
- REPAIR PIPING
- ADD FITTINGS
- TEST PIPING & VESSELS
- PROPEL PIGS BY COMPRESSED AIR


TEETH OF ANCHOR RING GRIP PIPE AS EXPANDER NUT IS TIGHTENED
EXPANDER NUT
TUBULAR SHAFT
NEOPRENE SEALING ELEMENT
PIPE PLUG

*COLD WATER, NON SHOCK TEST MADE IN 12¾" O.D. STANDARD WEIGHT LINE PIPE.

WRITE FOR BULLETIN AND PRESSURE RATINGS OF ALL SIZES

T.D. Williamson, Inc.

P. O. BOX 4038 TULSA 9, OKLAHOMA

REPRESENTATIVES: Houston • Pittsburgh • Plainfield, N. J. • Amarillo • Casper • Provo, Utah • Joliet, Illinois • Los Angeles • San Francisco • Bartlesville, Okla. • Edmonton • Toronto Calgary • Buenos Aires • Durban, Natal, South Africa

EXTRA MILES...

WITH PEAK MOBILE RADIO POWER

★ 100 WATT POWER OUTPUT ★ MAXIMUM RANGE

★ EXTENDED COVERAGE ★ TOP RECEIVER SENSITIVITY

Motorola "TWIN-V" radiophone—with highest power, to push the range of your VHF radio system to its maximum—to optimize mobile-to-base and mobile-to-mobile communications in the farthest fringe areas.

Here peak receiver sensitivity combines with highest transmitter output to assure dependable reception of all communications. Advanced design provides full 100 watt rated output. Yet the economical battery drain is comparable to conventional 60 watt equipment—plus full 6/12 volt interchangeable operation, without changes or modifications, for obsolescence protection in mixed fleets.

The 25-54 mc. 100 watt mobile radio equipment includes all the forward-looking engineering of the "TWIN-V" radiophone line:

- **Conservative long-life design**
- **Reserve performance**
- **Minimum maintenance requirements**
- **"On-channel" stability**
- **Crisp, clear voice reproduction**
- **Rugged construction**
- **Dependability through the years**

Twin-V RADIOPHONE 6 12

These and many other features have made "TWIN-V" radiophone the choice of most mobile radio users—features which become more strikingly evident as experience continues to prove their merits.

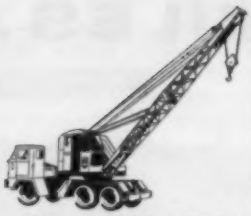
And Motorola is your *complete* supplier—with the proper equipment for every radio system, plus parts, maintenance, financing, service and engineering available for every application. Write, phone or wire—TODAY!

MOTOROLA

2-WAY RADIO

MOTOROLA COMMUNICATIONS & ELECTRONICS, INC.
A SUBSIDIARY OF MOTOROLA, INC.
4501 AUGUSTA BOULEVARD • CHICAGO 51, ILLINOIS

Motorola consistently supplies more mobile and portable radio than all others combined.
Proof of acceptance, experience and quality.
The only COMPLETE radio communications service—specialized engineering . . . product . . . customer service . . . parts . . . installation . . . maintenance . . . finance . . . lease.
"The best costs you less—specify Motorola."



T-35 CARRIER-MOUNTED BANTAM for high-speed mobility to get from one job to another. New heavy-duty model now available with a full 7-ton capacity on the "300" Carrier.

CR-35 NEW SELF-PROPELLED BANTAM for complete one-man operation. Has more money-saving advantages than you'll find in any other machine of its kind. Ideal for loading or unloading pipe from trucks or railroad cars.

Rugged and Dependable...

that's why pipeliners are buying BANTAMS

The word got around! More and more utility companies and pipeliners have discovered that speed and versatility in a Bantam have made it the most economical and handiest all-around machine for laying and maintaining service lines. Trenching with back hoe, lifting, loading or placing pipe as a crane, ditch-cleaning or digging bellholes with a clam—these and dozens of other assignments Bantam handles in a low-cost hurry. Works with 9 attachments. On crawler, truck or self-propelled mounting. Bantam lifts from 10,000 to 14,000 lbs.

The facts about Bantam's big production and low costs are available in actual cost records, yours for the asking. It's the most competitive rig in the business. Why delay the savings Bantam can bring you? Investigate now. Ask your Schield Bantam Distributor, or write us.

SCHIELD Bantam Co.

286 Park St., Waverly, Iowa, U.S.A.

World's Largest Producers of Truck Cranes and Excavators

Please send information on Bantams in pipeline and utility work.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

P-23-A

tery terminals, V_1 represents the open circuit voltage, $R_{1,1}$ which is the internal resistance between lines represents the internal battery resistance, and the bond resistance, R_B, represents the external resistance. The bond current thus is represented by:

$$I_1 = \frac{V_1}{R_B + R_{1,1}} \text{ amperes} \quad . \quad (3)$$

Since equations 2 and 3 are equal, they can be equated and solved for R_B:

$$\frac{\beta_{2,1} V_1}{R_{2,1}} = \frac{V_1}{R_B + R_{1,1}} \quad . \quad (4)$$

Therefore

$$R_B = \frac{R_{2,1}}{\beta_{2,1}} - R_{1,1} \text{ ohms} \quad . \quad (5)$$

This is the critical value of bond resistance needed to allow the proper magnitude of bond current to flow which will just cancel or nullify the exposure effect from interference current. Only the three network constants shown on the right side of equation 5 are needed to solve the bond problem and these are easily and quickly obtained by field test. Any value of resistance less than that given by equation 5 will allow more than the critical value of bond current to flow, with the result that cathodic protection will be obtained on the foreign line in the vicinity of terminals 2; and any value of bond resistance higher than that given by equation 5 will not permit sufficient bond current to flow to eliminate the total exposure, although it will be decreased.

Equation 5 shows that the critical value of bond resistance is independent of the voltage changes at terminals 1 and 2, as well as the magnitude of rectifier current. This condition holds, however, only where there is no residual or galvanic voltage between lines, and this very often is not the case.

It is seen that the only voltage involved in equation 4 is V_1 which is due to rectifier operation and this cancels out in solving for R_B. When a residual voltage is present between lines, equation 3 takes the form:

$$I_1 = \frac{E_1 + V_1}{R_B + R_{1,1}} \text{ amperes} \quad . \quad (6)$$

and equation 4 takes the form:

$$\frac{\beta_{2,1} V_1}{R_{2,1}} = \frac{E_1 + V_1}{R_B + R_{1,1}} \quad . \quad (7)$$

Where E_1 represents the residual or galvanic voltage between lines with neither bond nor rectifier current flowing. The solution for R_B, then is:

$$R_B = \frac{R_{2,1}(E_1 + V_1)}{\beta_{2,1} V_1} - R_{1,1} \text{ ohms} \quad . \quad (8)$$

The value of V_1 is obtained as explained previously, and the value of E_1 is obtained simply by measuring the

voltage at terminals 1 with no rectifier or test current flowing. This can be done by making a visual observation; or if it is suspected that this voltage is not constant, a recording meter is connected to measure the voltage over the desired period of time and the optimum value used in the bond calculations. In most cases it is advisable to make this recording in order that there will be no guess work involved.

Equation 5 shows that when no residual voltage exists between lines, rectifier current may be changed at will if cathodic protection requirements change with time without the need for changing the bond resistance. However, equation 8 shows that when a residual voltage does exist, a change in rectifier current will necessitate a change in bond resistance, but since all necessary data were obtained during the original field tests, the new value of bond resistance can be calculated without need for additional test work.

Another condition which should be considered if a complete solution to the bond problem is to be obtained is the fact that the effect of bond current upon the protected line is to decrease the amount of cathodic protection obtained from the rectifier. This becomes obvious when it is considered that, with respect to the foreign line and direction of bond current flow, the protected line is serving as an anode or ground bed.

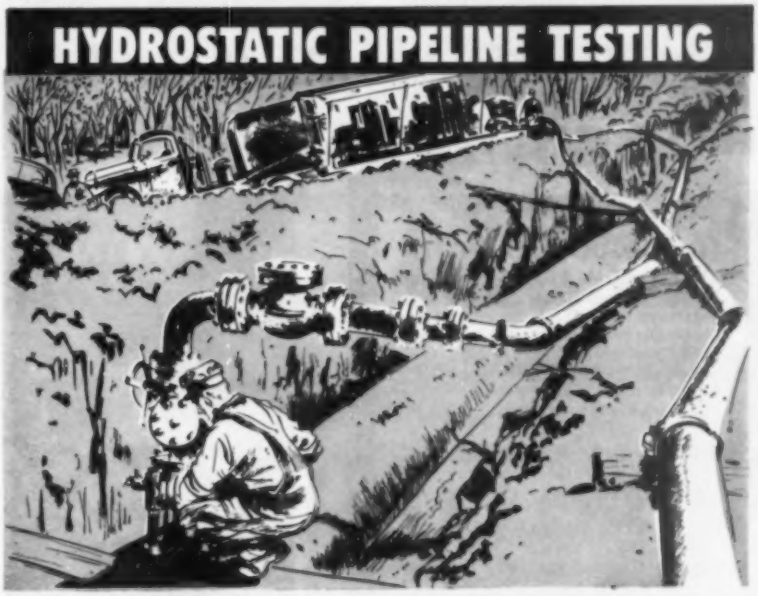
The net effect at any given place on the protected line, such as at terminals 4 in Fig. 1, is the algebraic sum of cathodic protection effect from rectifier current which will be positive, and the interference or exposure effect from bond current which will be negative. The bond effect is determined by connecting the test current generator or battery between lines with polarity such that current will flow from the foreign line through the generator onto the protected line. The test current, then, will have the same effect upon each line as bond current; therefore this effect can be measured by obtaining the ground voltage changes per unit current, or the network constants, at the various locations of interest.

With the test current source connected between lines at the same location where the bond is to be connected, a survey should first be conducted along the protected line in order to locate the point of maximum exposure caused by bond current. This is done in the same manner that the maximum exposure point was located on the foreign line caused by rectifier current. This location will usually, but not necessarily, be near the point of bond connection. Let this location be represented by terminals 4 in Fig. 1. The network constant, $R_{4,1}$, is then obtained. The net change in ground voltage at terminals 4 is then:

$$Vg_4 = I_2R_{4,2} + I_1R_{4,1} \text{ volts} \quad . \quad (9)$$

$R_{4,2}$ is the change in ground voltage at terminals 4 per unit rectifier current. When this is multiplied by total rectifier current, I_2, the product gives the component of ground voltage change due to the rectifier. $R_{4,1}$ is the change in ground voltage at terminals 4 per unit bond current and, likewise, the product of this and total bond current gives the component of change due to bond current. This latter component is of negative polarity as $R_{4,1}$ would be negative, thus the cathodic protection effect from the rectifier would be decreased.

If it is desired to maintain the same change in ground voltage at terminals 4 after the bond is installed as would be obtained without a bond, the rectifier current must be increased by some value above that which would be needed without a bond. However, this would cause an increase in bond current flow, therefore, an exact balance between rectifier current and bond current, or bond resistance, is necessary. The values for balance can be difficult to determine by field experiment but by determining the network constants and using a little algebra, the exact



Call Williams FOR A
BUTTONED UP JOB

ONE CALL to Williams and you can forget about testing. Our complete mobile equipment, experienced testing engineers, and 24-hour crews handle the entire testing procedure from preliminary engineering to making final reports.

Developed by Williams, this packaged service has been used by major pipeline companies on some of the longest and largest lines in the country.

Use Williams hydrostatic testing on new pipeline construction, rehabilitation of old lines, compressor stations, processing installations and plant expansion.

Call Shreveport 4-2678.

HYDROSTATIC PIPELINE TESTING

2000 Beck Building
Shreveport, Louisiana

Williams
PRESSURE SERVICE COMPANY

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

solution can easily be obtained.

Referring to Fig. 1, let I_3 be the value of rectifier current required for cathodic protection on the line to be protected, without regard for adverse interference effects on the foreign line. This value has been obtained from previous tests by using the particular criterion of protection which appeals to the engineer on the job — such as current value obtained from the null or polarization test, a ground voltage of .85 measured between pipe and copper-copper sulphate half cell placed either over the pipe or at a point out of the ground bed or pipe line potential gradient (remote earth), a change in ground voltage of certain value, current density, effect upon current profile, etc. Let I'_3 be the increased value of rectifier current needed not only to supply the cathodic protection desired but also to overcome the adverse effect from bond current.

After the location of maximum exposure or interference on the foreign line from rectifier current (terminals 2), and the location of maximum exposure on the protected line from bond current (terminals 4), the necessary network constants are measured, and these are: $R_{1,1}$, $R_{2,1}$, $R_{4,1}$, $R_{1,3}$, $R_{2,3}$, $R_{4,3}$, $\beta_{2,1}$, and E_1. The expression for ground voltage change at terminals 4 caused by rectifier current with no bond current flowing is given by:

$$Vg_4 = I_3 R_{4,3} \text{ volts} \quad . \quad . \quad . \quad . \quad (10)$$

The problem is to determine the increased amount of rectifier current required to produce the same magnitude of cathodic protection at terminals 4 with bond current flowing, as obtained without bond current as given by equation 10; value of bond current required; and the corresponding bond resistance needed to eliminate exposure on the foreign line. In terms of the network constants, these conditions are stated as follows:

$$I_3 R_{4,3} = I'_3 R_{4,3} + I_1 R_{4,1} \quad . \quad (11)$$

$$I'_3 R_{2,3} + I_1 R_{2,1} = 0 \quad . \quad . \quad . \quad (12)$$

In equation 11, $I_3 R_{4,3}$ represents the positive ground voltage change at terminals 4 caused by the rectifier current without bond current flowing. This is the final value required. $I'_3 R_{4,3}$ in equation 11 represents the positive change in ground voltage at terminals 4 caused by the increased value of rectifier current, and $I_1 R_{4,1}$ represents the negative ground voltage change at terminals 4 caused by bond current flow.

Equation 11 states algebraically that the final change in ground voltage at terminals 4 caused by both final rectifier and bond currents must be equal to the change caused by original rectifier current with no bond current flowing. In equation 12, $I'_3 R_{2,3}$ represents the negative ground voltage change at terminals 2 caused by rectifier current, and $I_1 R_{2,1}$ represents the positive ground voltage change at terminals 2 caused by bond current. Equation 12 states that the final ground voltage change at terminals 2 caused by both rectifier and bond currents is zero. In other words, the exposure caused by rectifier current is exactly offset by bond current.

Since there are two unknown quantities involved in two equations, I'_3 and I_1, a simultaneous algebraic solution of these equations gives the required values of rectifier and bond currents:

$$I'_3 = I_3 \frac{R_{4,3} R_{2,1}}{R_{4,3} R_{2,1} - R_{2,3} R_{4,1}} \text{ amp} \quad . \quad . \quad . \quad (13)$$

$$I_1 = -I_3 \frac{R_{4,3} R_{2,3}}{R_{4,3} R_{2,1} - R_{2,3} R_{4,1}} \text{ amp} \quad . \quad . \quad . \quad (14)$$

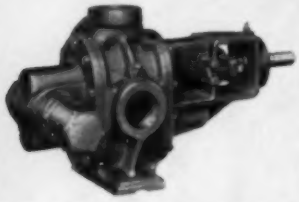
The value I'_3 is obtained in the field by tap adjustment of the rectifier. The value I_1 is obtained by inserting a resistance of proper value in the bond connection between lines at terminals 1. In accordance with the previous discussion, the current that would flow through a bond at terminals 1 would be:

Solve Your Pumping Problem with a

ROPER ROTARY PUMP

FOR REGULAR TRANSFER

The dependable Roper Series 3600 Pump — sizes 40 to 300 G.P.M., pressures to 90 P.S.I. Speedy, quiet, plenty rugged. Rotary gear principle permits operation in either direction. Self-lubricated by liquid pumped . . . self-priming . . . simple design permits quick, easy servicing.

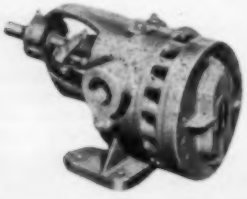


FOR MEDIUM TRANSFER

Roper Series F Pump—sizes 1 to 300 G.P.M., pressures to 300 P.S.I. Four-port design permits 8 optional piping arrangements . . . cuts installation time and costs. Equal size gears run in axial hydraulic balance. With packed box or mechanical seal; with or without relief valve.

FOR HEAVY TRANSFER

Roper Series H Pump — sizes 10 to 75 G.P.M., pressures to 1000 P.S.I. Ideally suited to those smaller diameter or long, high pressure gathering lines. Self-lubricated spur gears running in axial hydraulic balance, roller bearings and bronze wear plates contribute to efficiency and long service life. With packed box or mechanical seal.



SPECIFY ROPER

for truck transportation, stock tank transfer, and gathering line operations handling gasoline to heavy crude oils.

Geo. D. Roper Corporation
729 BLACKHAWK PARK AVENUE
ROCKFORD, ILLINOIS

ROPER Rotary Pumps

Sales and service in all oil producing areas

$$I_1 = -\frac{R_{1,3} I'_3 + E_1}{R_B + R_{1,1}} \text{ amp.} \quad (15)$$

where R_B is the required bond resistance. I_1 is a negative current for the reason that its effect is to decrease the open circuit voltage at the bond terminals. Since equations 14 and 15 are equal, they can be equated and solved for R_B. However, the simpler method of solving for R_B is to solve equation 12 for I_1, and then solve simultaneously with equation 15:

$$I_1 = \frac{-R_{2,3} I'_3}{R_{2,1}} \quad . \quad . \quad (16)$$

$$\frac{-R_{2,3} I'_3}{R_{2,1}} = -\frac{R_{1,3} I'_3 + E_1}{R_B + R_{1,1}}$$

$$R_B = \frac{(R_{1,3} I'_3 + E_1) R_{2,1}}{R_{2,3} I'_3} \text{ ohms}$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Equations 13 and 17 give the final values required to complete the field installation. If the design and installation has been carried through properly, no change in ground voltage at terminals 2 will be observed as the rectifier is turned on and off.

Field test Example

An actual example of a field test showing how the data are taken and recorded, and the network constants computed for use in the final calculations is shown in Fig. 2 and Fig. 3.

Cathodic protection is to be applied to pipe line A, and terminals 1 represent the test current generator or rectifier terminals. Pipe line B is a lateral that ties in to pipe line A but since it is not to be protected, the tie-in is made through an insulated flange as shown. Terminals 2 represent the terminals of the voltmeter to be used for measuring voltage between the pipe lines.

Automobile storage batteries were used as a source of test current at terminals 1 and while this current was turned on and off, a survey of ground voltage on pipe line B showed that maximum exposure would occur at terminals 4. Likewise, test current was introduced between lines at terminals 2 and while this was turned on and off a survey along pipe line A showed that maximum exposure from bond current would occur at terminals 3. Terminals 5 are at the farthest place on pipe line A where protection is to be obtained.

It should be noted that the *type* of reference electrode or half cell used for making earth contact while measuring ground voltage is immaterial. It is the *change* in ground voltage caused by rectifier and bond current flow that is required and in this case the half cell potential cancels out.

A copper-copper sulphate electrode, a steel bar, valve box, or—if a vacuum tube voltmeter is used—a weed growing in the earth, can be used for the ground connection. The important thing is that the same site be used each time comparative readings or tests are made, and that the proper correction factors be applied to voltmeter readings when the internal meter resistance is low in comparison with the external meter circuit resistance.

The problem is to determine the magnitude of rectifier current required to produce a 4 volt change at terminals 5 with bond current flowing from pipe line B to pipe line A at terminals 2, and to determine the magnitude of bond current and corresponding bond resistance required to eliminate exposure at terminals 4. A 4 volt change is required at terminals 5 in order to eliminate exposure caused by stray railway current. The problem is stated mathematically by two equations:

$$I_1 R_{5,1} = Vg_5 + I_2 R_{5,2} \quad . \quad . \quad (18)$$

and

$$I_2 R_{4,2} = I_1 R_{4,1} \quad . \quad . \quad . \quad . \quad . \quad (19)$$

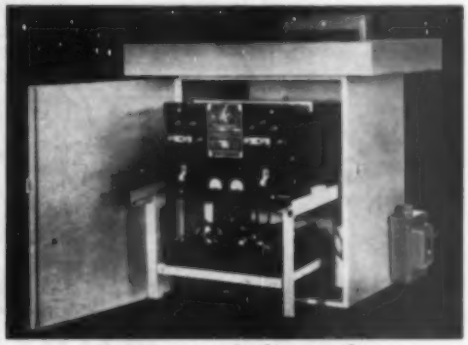
Equation 18 states that, at terminals 5, the product of total rectifier current and ground voltage change per ampere of rectifier current is equal to the 4-v change required (Vg_5) plus the ad-

EXTRA *DEPENDABILITY*

FOR ANY CATHODIC PROTECTION PROGRAM

HOLCOMBE SELENIUM RECTIFIERS

Small size steel cabinet rectifier.



Medium size steel cabinet rectifier.

Backed by fourteen years' experience in corrosion prevention, Holcombe rectifiers are soundly designed, ruggedly built, and carry an exceptionally long term warranty. That's why you'll find them all over the country, in use by major oil, pipeline and industrial firms. No matter what your rectifier application may be, there's just the right Holcombe unit to fit the job. Available in all sizes, they are made with cabinets of cadmium plated steel or aluminum. *Write for new literature on Holcombe rectifiers and other corrosion products.*

THE HOLCOMBE COMPANY, INC.

FIRST NATIONAL BANK BUILDING TELEPHONE 5-3468
SHREVEPORT, LOUISIANA

RECTIFIER DIVISION 617 MONTGOMERY ST. TEL 4-1477

HOLCOMBE COMPANY OF CANADA, INC.

323 BARKER BUILDING TELEPHONE 6-7291
CALGARY, ALBERTA, CANADA

Lion Coatings • Holcombe Selenium Rectifiers
Pipe Wrappings • Graphite Anodes • Coke Breeze

verse effect caused by bond current. Equation 19 states that the adverse effect at terminals 4 caused by rectifier current will be offset by the beneficial effect caused by bond current.

It will be noted when analyzing the field data in Fig. 2 and Fig. 3 that Vg_5 and the network constants, $R_{5,2}$ and $R_{4,1}$, which describe exposure effects at terminals 3, 4, and 5, are negative. These signs are disregarded, however, when the constants are used in the equations because they are placed on the opposite sides of the equations from the positive constants, $R_{5,1}$ and $R_{4,2}$. To be mathematically rigorous, the equations can be put in the forms:

$$I_1 R_{5,1} + Vg_5 + I_2 R_{5,2} = 0$$

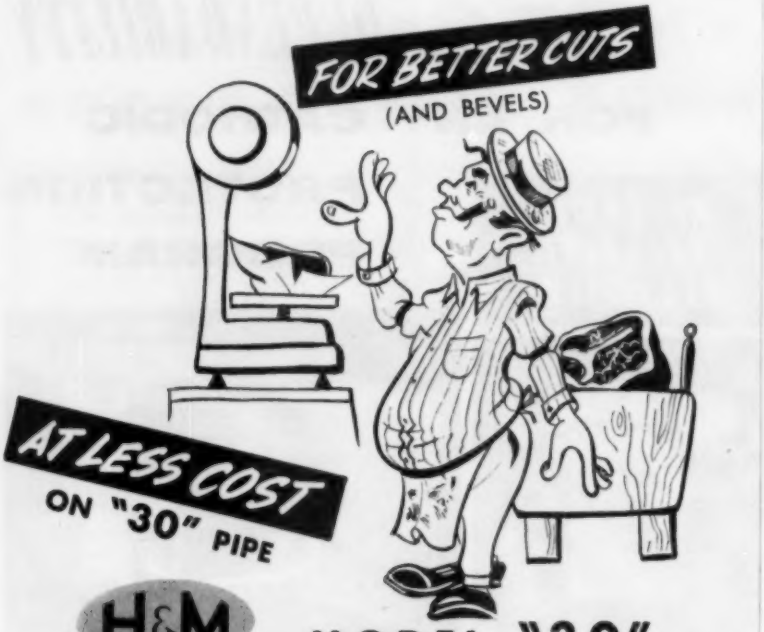
and

$$I_2 R_{4,2} + I_1 R_{4,1} = 0$$

and then the correct signs as determined from field test are used when the constants are placed in the equations. Vg_5 is called negative, or exposure, because the earth is negative to the pipe by that magnitude, and it is the purpose of the rectifier to change the voltage between pipe and earth by 4 volts in order to eliminate the possibility of corrosion.

An easy method of solution is to solve equations 18 and 19 simultaneously for I_1:

$$I_1 = \frac{Vg_5 R_{4,2}}{R_{4,2} R_{5,1} - R_{4,1} R_{5,2}} \quad . \quad (20$$



H&M MODEL "30"

You're "paying for the butcher's thumb" when you use *oversized equipment* on 30" pipe cutting and beveling operations! — because H&M Model "30" is designed *specifically* for the 26" to 30" range of pipe — *at lower cost.*

The increasingly widespread use of 30" pipe on gas transmission lines demands specialized equipment for greater savings, more speed and efficiency.

So, H&M now offers its Model "30", built on the same split-gear principle as all H&M machines, and with the same lightweight but rugged construction, with same ease of operation and economy in both field and shop.

WRITE FOR ILLUSTRATED BULLETINS ON THE COMPLETE H & M LINE

- PIPE CUTTING & BEVELING MACHINES From 1½" to 36"
- SHAPE CUTTER
- OUT-OF-ROUND
- FLEXIBLE SHAFT
- MOTORIZED UNITS

PAT. PENDING

LIGHT AS A FEATHER

H&M T M REG

PIPE BEVELING MACHINE CO.

311 E. THIRD ST. • TULSA • Diamond 3-0241

Substituting the network constants obtained from the data sheets Fig. 2 and Fig. 3:

$$I_1 = \frac{.4 \times .292}{.292 \times .403 - .0894 \times .146}$$

$= 11.2$ amperes rectifier current required.

Now, solve equation 19 for I_2:

$$I_2 = \frac{I_1 R_{4,1}}{R_{4,2}} \quad . \quad . \quad (21)$$

Substituting the network constants and the value for I_1:

$$I_2 = \frac{11.2 \times .0894}{.292}$$

$= 3.4$ amperes bond current required.

As explained previously, the equation for bond resistance is derived by solving the bond current equation:

$$I_2 = \frac{E_2 + I_1 R_{2,1}}{B_2 + R_{2,2}} \quad . \quad (22)$$

Therefore

$$B_2 = \frac{E_2 + I_1 R_{2,1}}{I_2} - R_{2,2} \text{ ohms}$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

where B_2 = bond resistance to be connected between pipe lines.

Substituting the network constants:

$$B_2 = \frac{3 + 11.2 \times .123}{3.4} - .360$$

$= .93$ ohms bond resistance.

The final ground voltage change at terminals 3 resulting from the algebraic sum of beneficial effect due to rectifier current, and the adverse effect due to bond current, can be determined from the equation:

$$Vg_3 = I_1 R_{3,1} + I_2 R_{3,2}$$

$$Vg_3 = 11.2 \times .0824 - 3.4 \times .127$$

$= .49$ volts.

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

It will be observed on the field data sheets that ten readings were taken at each location, and that the network constants were derived from the averages of the ten readings. This was necessary because stray railway current effects caused the meter points to fluctuate continually and thus no single reading could be relied upon for accuracy. Even when stray currents are not present, it is advisable to take several readings at each set-up in order that errors in observation and recording can be discovered.

The mathematical expression for the method used for computing the constants from the field data is:

$$R_{a,b} = \frac{\Sigma \Delta Vg_a}{\Sigma \Delta I_b}$$

Acknowledgment

This discussion was presented at the AGA Distribution, Motor Vehicles and Corrosion Conference, Chicago, Illinois, 1956. ★ ★ ★

PIPE LINE COMMUNICATION & CONTROL

Microwave towers and suspension bridges can be hazardous to air and marine navigation, but not if identified by...

Beacons and Paint

C. E. Upson

General Superintendent of Communications
Texas Illinois Natural Gas Pipeline Co.

ONE of the little-known, but highly important, functions of a gas transmission company is the marking of microwave towers and pipe line suspension bridges, which have characteristics considered hazardous to marine and air navigation.

Several elements determine these hazards, such as height, distance to nearest airport, location of other structures, and the general size and shape of the structure.

The Civil Aeronautics Administration and United States Coast Guard, in their roles of promoting and enforcing safety in air and water commerce, have certain specifications with which all pipe line companies must comply.

Microwave towers on Natural Gas Pipeline Company of America and Texas Illinois Natural Gas Pipeline Company systems are painted for daylight marking. This is done with seven alternate bands of international orange and white of equal width, with the band of each end colored orange. This provides visibility from aircraft at any angle of approach.

Also on Texas Illinois Natural Gas Pipeline, CAA requires painting of the main towers of the system's four pipe line suspension bridges: Across the Colorado River, near Glenfora, Texas; Brazos River, near Simonton, Texas; Red River, near Fulton, Arkansas, and the Mississippi River, near Grand Tower, Illinois. The main towers on these bridges range from 85 to 265 ft.

The purpose of lighting an obstruction is to provide a standard warning to airmen during limited daylight and darkness.

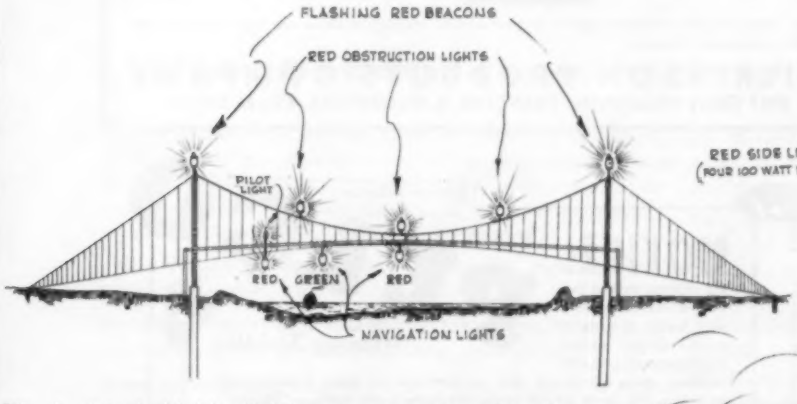


FIG. 1. A typical bridge lighting arrangement consists of a green light at the center of the navigable channel under each span, and a red light at each margin.

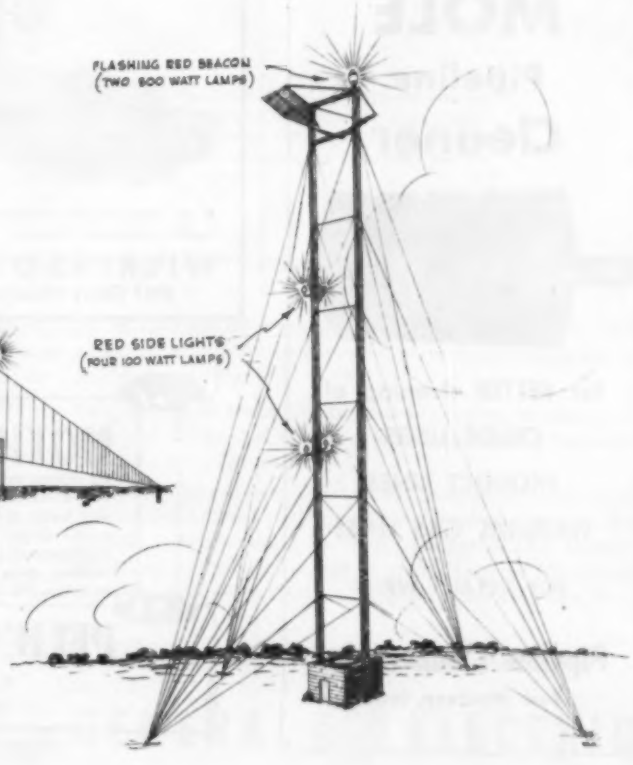


FIG. 2. Typical microwave tower lighting layout. A flashing beacon is mounted at the uppermost point of the structure, with side lights mounted at one-third and two-thirds levels.

Maintenance man is making a scheduled inspection and lamp replacement on a main tower of a suspension bridge. Additional obstruction lights outlining the contour of the superstructure of each span are spaced at regular intervals on the main suspension cables.

On the Texas Illinois system, 26 of 38 microwave towers are lighted; on the Natural Gas Pipeline system, 12 of its 14. These towers range in height from 100 to 300 ft.

The bridge spans across the Mississippi and Red rivers also require lighting in accordance with CAA specifications. Moreover, as prescribed by the Commandant of each Coast Guard district, all structures over navigable waters throughout the United States must have lighting.

Each fixed bridge span requires a green light at the center of the navigable channel under each span, and a red light at each margin. (See Fig. 1). The Mississippi River is the only structure requiring marine navigation lights.

A typical microwave tower lighting calls for a flashing beacon mounted at the uppermost point of the structure, with side lights mounted at one-third and two-thirds levels. (See Fig. 2).

Typical suspension bridge lighting provides flashing beacons atop each main tower with obstruction lights at regular intervals on the main suspension cables between. (Fig. 1).

The CAA requires that two lights be installed at each point of marking. It also requires that all light operations be checked at least once every 24 hours, either by visual observation or through an automatic alarm device.

Each unattended lighted tower on the microwave systems is connected to an alarm circuit, which senses a light failure and transmits an alarm to an attended location. From here maintenance personnel are sent to make the repair.

Pipe line suspension bridges, however, are situated at points on the Texas Illinois system where automatic alarm transmission is impracticable.

Consequently, with CAA's approval, a rather intricate system of maintaining proper obstruction lighting at those unattended locations has been constructed. This consists of two flashing red beacons on each bridge tower — a main and a standby — each containing 500-watt lamps. The standby beacons come into service automatically when either or both lamps in the main

MOLE
Pipeline
Cleaner

for BETTER cleaning of
CRUDE LINES
PRODUCT LINES
NATURAL GAS LINES

FOR DETAILS WRITE

Pipeline Cleaners Co.
Fort Madison, Iowa

The WILKINSON LINE LOCATOR
SEES AND TELLS

Instantly locates subsurface pipes, cables and such, and determines depth accurately. The etched circuitry, our latest innovation, assures better quality control and performance than the customary hand wiring method.

Avoid damaged structures and prevent loss of time with the Wilkinson Locator.

A new loop antenna increases power and selectivity. Instrument cases are now built of wear resisting phenolic material.

WILKINSON PRODUCTS COMPANY
3987 Chevy Chase Drive, PASADENA 3, CALIFORNIA. SYlvan 0-4314

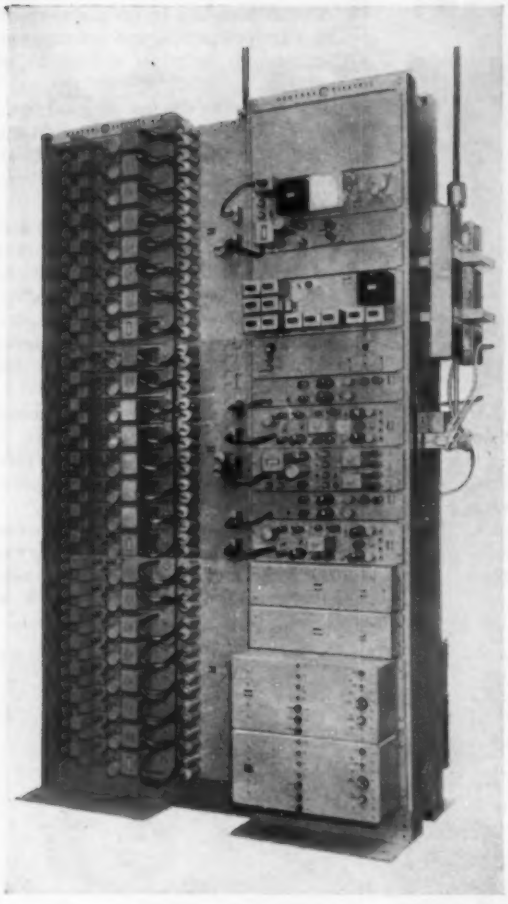
NOTICE:
No change except the corporate name. We still have the same ownership, same management, same address, same telephone, and use the same 45 years of experience to render the same service under the same trade name—"PELCO."

Specify **PELCO** Welding Saddles

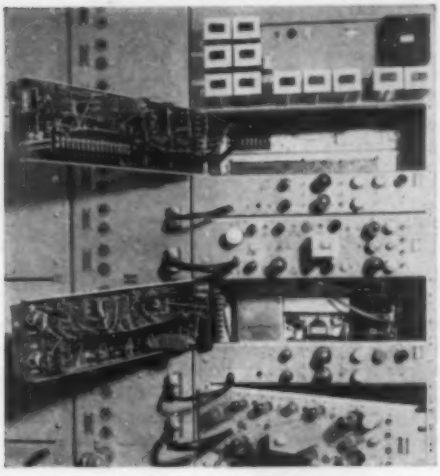
PELICAN SUPPLY CO. INC.
P. O. Drawer 1108 Shreveport (84), La.
SEE YOUR NEAREST SUPPLY HOUSE

(Formerly: Pelican Well Tool & Supply Company)

IMPROVE·YOUR MICROWAVE·RELIABILITY WITH G-E QUADRIPHASE*



*The new General Electric Quadriphase system utilizes four 9 KC sine waves phased in quadrature for selection of the individual channels.



▲ New ease of servicing—units arranged to slide out or swing out for service or inspection without interrupting operation.

◀ G-E 25-channel, 2000 MC Quadriphase microwave terminal, showing all multiplex equipment. Normal and standby transmitters, receivers, power supplies and termination units are mounted on the other side of these racks.

Highly stable channel-determining concept increases "On-The-Air" time

NEW General Electric Quadriphase is the only multiplexing system with channel selection determined by resistance circuits alone. There are no L-C networks . . . no tuned circuits . . . and no delay lines. As a result, you get more reliable microwave communication.

G-E engineers report numerous benefits from the new Quadriphase multiplex design—

MAXIMUM STABILITY AND RELIABILITY—far greater than is possible in multiplex systems requiring tuned circuits.

FEWER CHANNEL ADJUSTMENTS—only 2 necessary—one on the audio level in, and one out.

FEWER TUBES in multiplex, transmitter, and receiver. Total—less than 8 per voice channel!

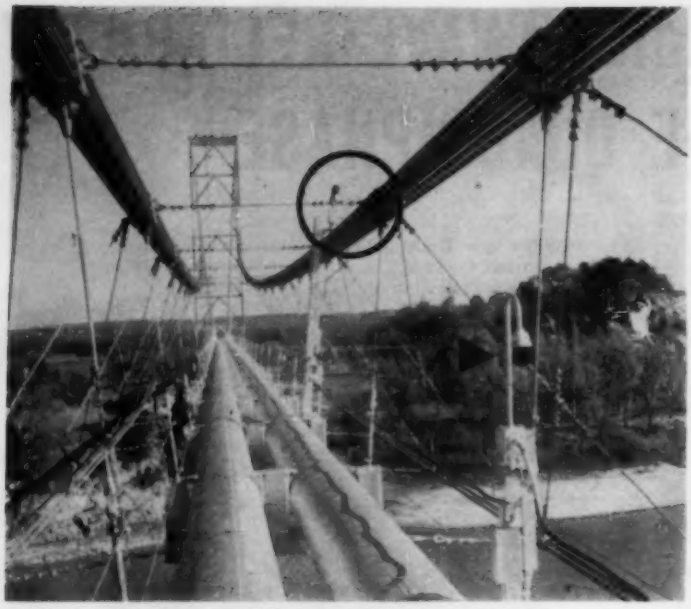
FAR LESS MAINTENANCE TIME AND EXPENSE—You save on tube inventory and on maintenance time. Because every tube is used well below its maximum rating, G-E Quadriphase gives you a big safety margin, and extra tube life. Simplified circuitry including new printed circuits means quick checking and servicing.

30% LESS FLOOR SPACE FOR RACKS—Packaging is compact—only 4 racks instead of 6 required in previous 25-channel microwave equipment.

See for yourself how to get more reliable microwave communication at less operating and maintenance expense. For complete details about the new concept of G-E Quadriphase, write today. *General Electric Company, Microwave Equipment, Section X9296, Electronics Park, Syracuse, N.Y.*

Progress Is Our Most Important Product

GENERAL ELECTRIC



Mid-span Obstruction light (circled) is shown above main suspension cable group at Mississippi River crossing. Each obstruction light consists of a 100-watt lamp, enclosed in an aviation red globe. These are mounted in pairs, one on each side of the obstruction. A pilot warning light (arrow) automatically goes on if a beacon light fails. Extremely foggy weather frequently prevails at this crossing, making visual checking of beacons impossible. This device, at a much lower level than the beacons, enables maintenance personnel to determine whether beacons are functioning properly from vantage points on the ground.

beacon fail. This insures continuous service.

The complete obstruction lighting system on each bridge is inspected at least every ten days.

Photoelectric cells automatically control the lighting on all structures when a predetermined intensity or lack of intensity of illumination is reached.

Special long-life lamps are used on all tower applications and are replaced at six-month intervals regardless of condition.

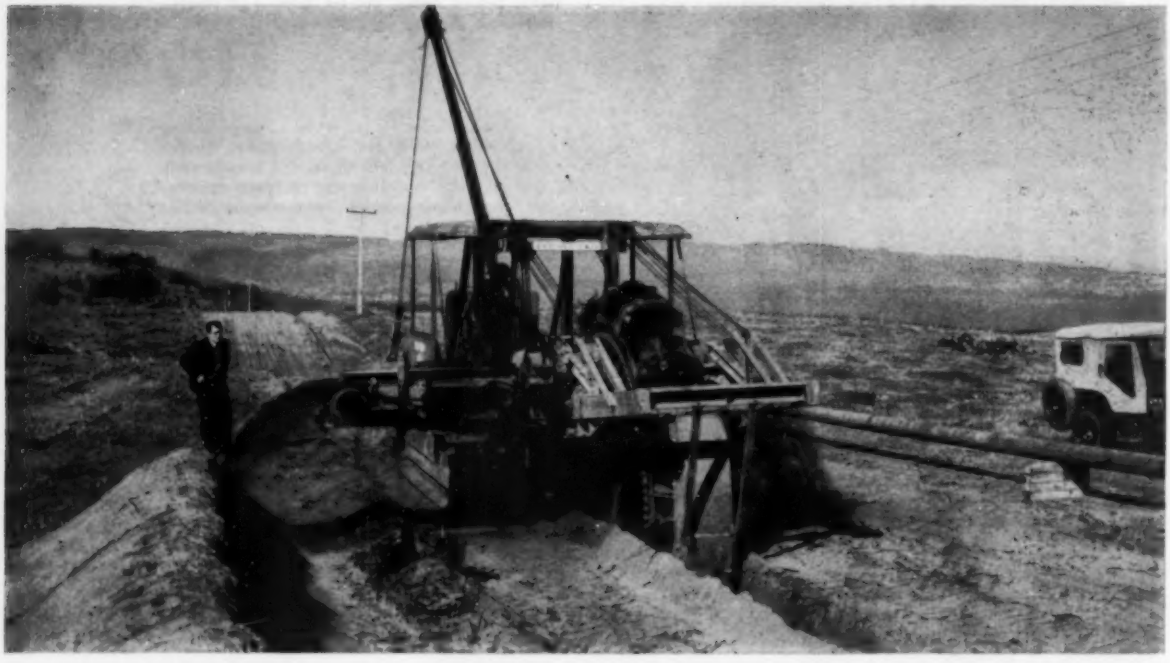
By combining the use of good basic equipment with frequent inspection and preventive maintenance, practically all instances of lamp failure are eliminated.

The responsibility for operation and maintenance of all microwave tower lighting lies with the communications division of the two pipe line companies. Pipe line personnel are responsible for bridge lighting, but whenever possible communications crews also perform this work.

Through the companies' continued cooperation with CAA and the U. S. Coast Guard, maximum safety is provided the public, as well as the companies' personnel and properties.

Acknowledgment is made to *Between the Lines*, employee publication for the illustrations and information contained in this article.

★ ★ ★



EMPRESA NACIONAL DEL PETROLEO of Santiago, Chile use their two Cleveland 320 trenchers on many different kinds of pipeline projects. Operating from Magallanes and Concon, the Clevelands dig a wide variety of trench lengths, depths and widths for crude oil, fuel oil, products and natural gas lines. The 320 shown here is digging a 17-kilometer crude oil line between ENAP's refinery at Concon and their Sea Terminal on Quintero Bay.

THE CLEVELAND TRENCHER COMPANY, 20100 St. Clair Avenue, Cleveland 17, Ohio

Experience can keep you out of trouble in fighting corrosion, too.

Why gamble with "unknown quantities" when it comes to protecting pipe, pipe joints, couplings and other vulnerable surfaces above and below ground?

Since 1941, TAPECOAT, the quality coal tar coating in handy tape form, has demonstrated its ability to withstand corrosion year after year. In case after case, TAPECOATed lines have been dug up after 10 years of service *with no signs of deterioration on the pipe surfaces uncovered.* That's why TAPECOAT is specified by those who know that continuing protection is the first consideration.

Everything considered, you'll be money ahead by using TAPECOAT to give you the quality protection you need for reduced maintenance and replacement cost.

Write for brochure and prices.

The TAPECOAT® *Company*

Originators of Coal Tar Coating in Tape Form

1533 Lyons Street
Evanston, Illinois

DO YOU WORK WITH ELECTRONIC EQUIPMENT?

you need these two new RCA

TUBE BOOKLETS!

Important additions to your technical library, these two new RCA publications contain valuable data and descriptions of approximately 300 RCA tubes as applied to industrial electronics.

RCA Power and Gas Tubes (PG-101B)—24-page book contains descriptions, terminal connections, technical information on 178 RCA vacuum power tubes, rectifier tubes, thyratrons, ignitrons, magnetrons, and vacuum-gauge tubes. The most up-to-date book of its kind in the industry.

Receiving-Type Tubes for INDUSTRY and Communications (RIT-104)—New, up-to-the-minute technical information on 126 RCA receiving-type tubes especially suited to industrial electronics. Includes technical data, socket connection diagrams, and descriptions on RCA Special Reds, Premium, computer, pencil, and glow-discharge, small thyratrons, low-microphonic, and other tube types.

Write on your company letterhead to RCA, Commercial Engineering Section I-78 T, Harrison, N. J., for a complimentary copy of RIT-104 and PG-101B.

SEND FOR THESE BOOKLETS TODAY!

RCA **TUBES FOR INDUSTRY**
RADIO CORPORATION OF AMERICA

RCA ELECTRON TUBES...LONG-LASTING, DEPENDABLE...AVAILABLE THROUGH YOUR AUTHORIZED RCA TUBE DISTRIBUTOR.

Do the controls you specify carry these listings?

UL

SA

MERCOID PRESSURE AND TEMPERATURE CONTROLS

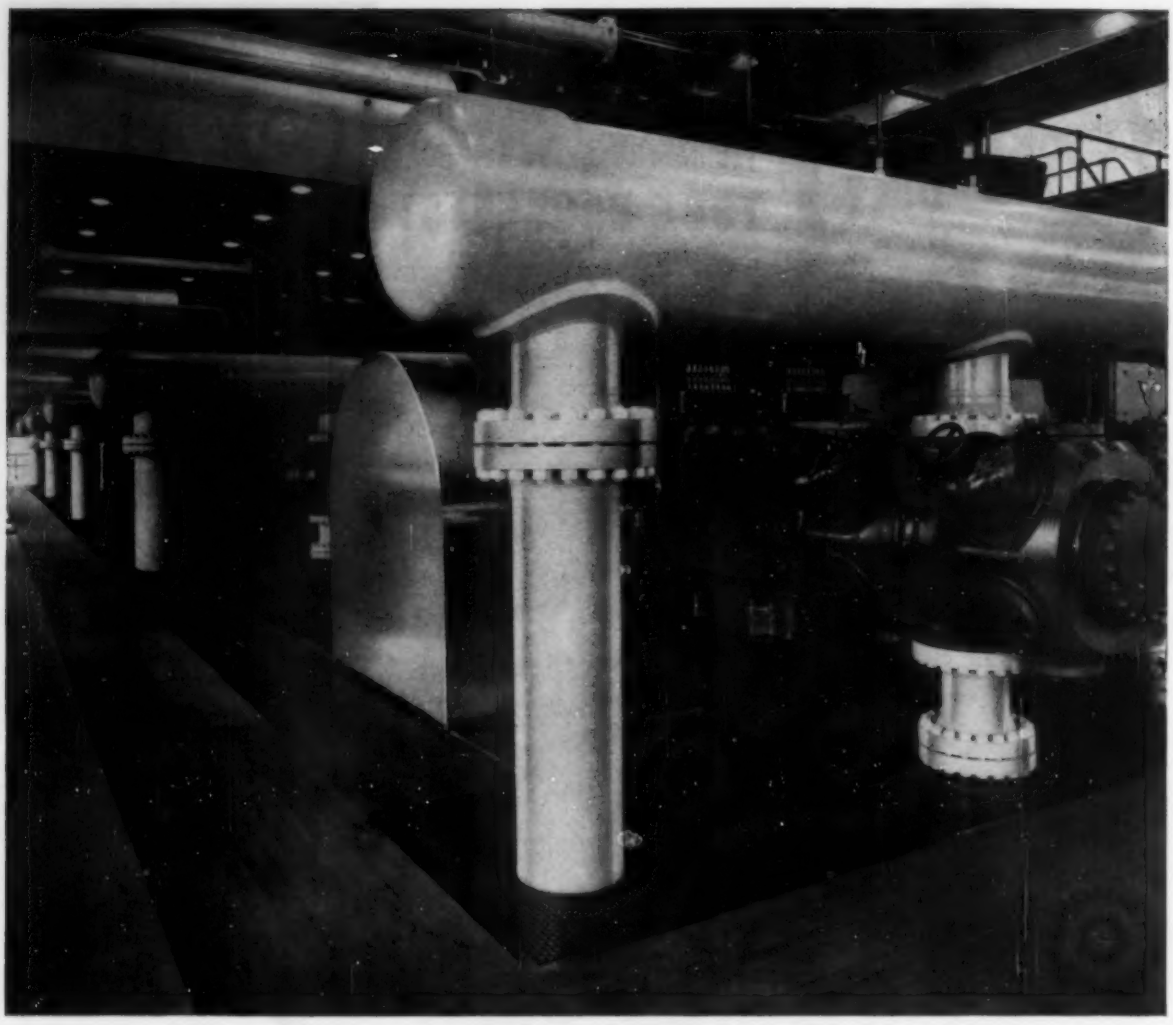
MERCOID TYPES DAE AND DSE
FOR HAZARDOUS LOCATIONS
N. E. CODE
Class I, Group D (NEMA 7)
Class II, Group E, F, G (NEMA 9, 9A)

ALSO
MERCOID TYPES DA AND DS
GENERAL PURPOSE
NEMA 1,
For indoor service and other general purpose applications

EQUIPPED WITH SEALED MERCURY CONTACT SWITCHES

Write For Catalog No. 856

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.



When Pritchard Plans and Builds Your Compressor Station . . .

You Save Time, Effort and Money

Pritchard's high caliber planning and top-notch performance record in the designing and construction of compressor stations means bigger savings to you in time, effort and money. And, the job is done the way you want it.

Every segment of planning and installation of your gas facility is completed by Pritchard's highly skilled, experienced personnel on a carefully coordinated engineering, purchasing and construction schedule. The end result of this planning and coordination is that the job is done to your complete satisfaction.

When you plan to build a compressor station . . . and want the job done right, right on time . . . choose Pritchard.

J. F. PRITCHARD & COMPANY
4625 Roanoke Parkway Kansas City 12, Mo.

Pritchard knows how to get a job done right . . . right on time!

Time after time natural gas companies that have had any experience at all with the Pritchard organization have come back for more when they expanded or modernized.

Why?

Because Pritchard knows how to get the job done right, right on time.

And, Pritchard's complete package contract means that each part of planning and installation is done on a carefully co-ordinated engineering, purchasing and construction schedule.

Pritchard is ready to offer you the same type of high caliber planning!

WRITE FOR PROOF!

Write today for a typical example of how you save time and money with Pritchard's complete package contract.

J.F. Pritchard & Co.
ENGINEERS & CONSTRUCTORS
Dept. 544, 4625 Roanoke Parkway
Kansas City 12, Missouri

Pipe Line Projects

Four Corners to Salt Lake Pipe Line Announced

Pacific Northwest Pipeline Corporation, through its subsidiary Northwest Production Corporation, has formed Northwest Pipeline Corporation to construct and operate a new crude oil and products line from the Four Corners area to Salt Lake City, Utah.

Northwest Pipeline will transport crude oil now being developed in southeastern Utah and northwestern New Mexico to refineries in the Salt Lake area. In addition, the line will carry products that will be produced in Pacific's Ignacio, Colorado, gasoline plant.

Initial capacity of the 8-in., 350-mile line will be 15,000 bbl a day. Pacific estimates that the facilities will be in operation within 12 months, depending on availability of materials. Cost of the system, including pump stations and storage facilities, is estimated at $15,000,000 by the Fish Engineering Corporation, designers of Pacific's natural gas line.

The new line will originate at Pacific's Ignacio Gasoline Plant south of Durango, Colorado, and will go direct to the refining center at Salt Lake City.

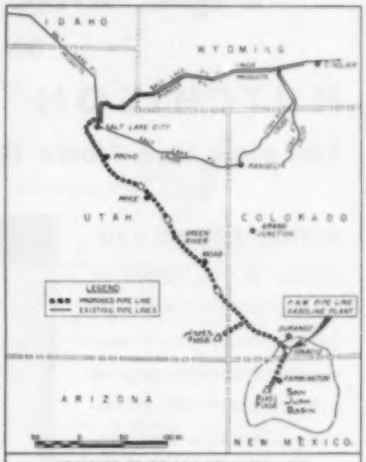
Pacific officials cite the move as a logical expansion of its operation in the area, as one-third of the new line will be constructed on Pacific's existing right-of-way. In addition to this, Pacific has substantial volumes of products to be moved to market.

The proposed facilities will tie in with existing pipe lines to marketing outlets serving major centers in the Pacific Northwest area. Lateral lines will connect the Bisti field in northwestern New Mexico and the Aneth field in southeastern Utah to the main line.

Operators in the Four Corners area have long been hampered by lack of transport as major markets have been almost inaccessible except by truck. The new facilities will make major Utah crude supplies available to Utah markets, moving the oil by the most direct route and providing an additional source of supply for the rapidly expanding markets.

Refiners in the Salt Lake area have indicated that crude moving through the line will find a ready market in the Intermountain area.

Reservoir engineers estimate oil reserves in the Four Corners area to be more than sufficient for initial pipe line requirements. Initially, the line will be powered to move approximately 8000 bbl of crude a day and about 7000 bbl of light products from Pacific Northwest's gasoline plant in the San Juan Basin. The line can be increased in capacity to 25,000 bbl a day by adding pump stations should reserves in the area warrant such expansion.



PROPOSED CRUDE AND PRODUCTS LINE FOUR CORNERS AREA TO SALT LAKE CITY

Short Gas Line Approved by FPC

Washington Gas Light Company, of Washington, D. C., has been granted authority by the Federal Power Commission to construct and operate 28.8 miles of pipe line in Virginia at an estimated cost of $3,380,000.

The proposed facilities consist of approximately 26.1 miles of 24-in. from the metering station of Atlantic Seaboard Corporation near Dranesville, Virginia, to a point near Washington where 2.7 miles of 20-in. line will connect it with a line leading to District of Columbia facilities.

Line and Compressor Program Approved

Federal Power Commission has granted authority to Cities Service Gas Company, Oklahoma City, Oklahoma, to construct and operate $1,423,300 natural gas facilities in Oklahoma.

The proposed construction consists of 11.77 miles of 30-in. pipe line to replace an existing 20-in. line; 17 miles of 20-in. loop line in Logan County, and the addition of turbocharging equipment to two 1100-hp compressor units in its Edmond station in Oklahoma County; 250 hp will be added to each unit.

Solve All Your Pipe Line Problems

ON THE

HUTCHISON CALCULATOR

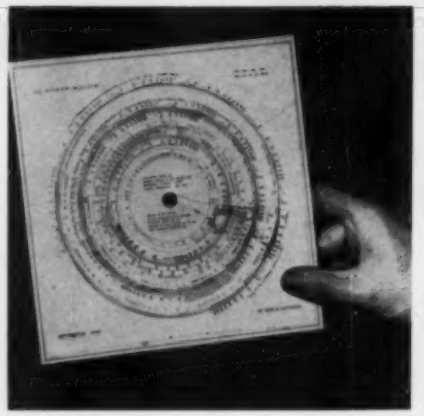
For Pipe Line Flows Gas, Air, Oil and Water

ACTUAL SIZE 10" x 10"

Printed in two colors on warp-proof Vinylite; scales are protected by transparent lamination, making erasure practically impossible. Complete with protectors, pressure table and instructions . . .

$10.00

Copyrighted 1950



Quick, Accurate, Easily Operated

Solves Problems In:

(1) High pressure gas pipe line flow by
  (a) Use of the Panhandle Formula or by
  (b) Use of the Weymouth Formula

(2) Low pressure gas pipe line flow by the use of the Spitzglass Formula

(3) Simple oil flow by National Transit Formula

(4) Flow of water in pipe lines by the use of the Spitzglass Formula

It will correct for the specific gravity of gas

It will correct for pressure base in gas problems

It will correct for interval distribution in high or low pressure gas or water systems

It will give hourly or daily results for gas and oil

It will solve many special problems easily

CLIP THIS AND MAIL TO:

THE PETROLEUM ENGINEER PUBLISHING COMPANY

Post Office Box 1589 • Dallas 21, Texas

Gentlemen: Please send me the Hutchison gas, air, oil and water flows calculator.

☐ $10 payment enclosed ☐ Bill me ☐ Bill company

Name _____ Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

Projects

Mountain Fuel to Connect With Pacific Northwest Line

The Federal Power Commission has granted temporary authority to Mountain Fuel Supply Company, of Salt Lake City, Utah, to build pipe line facilities to enable it to take 58,750,000 cu ft of natural gas per day from Pacific Northwest Pipeline Corporation, for delivery to distribution areas in southwestern Wyoming and Utah.

Facilities will include about 38 miles of pipe line and 2640 hp in compressor capacity at an existing station. Mountain Fuel will construct an interconnection with Pacific Northwest's system in Sweetwater County, Wyoming, to take delivery of the gas.

Cities Service to Expand in Midwestern States

The Federal Power Commission has granted temporary authority to Cities Service Gas Company, of Oklahoma City, Oklahoma, for the construction of natural gas facilities in Kansas, Missouri, and Oklahoma.

The proposed construction consists of the drilling and connecting of 55 injection and withdrawal gas wells in the McLouth storage field, in Leavenworth and Jefferson counties, Kansas; the installation of 6750 compressor hp in stations in Leavenworth and Anderson counties, Kansas, Cass County, Missouri, and Oklahoma County, Oklahoma; the construction of approximately 25 miles of 16-in. pipe line in Buchanan County, Missouri, 3.4 miles of 16-in. in Platte and Leavenworth counties, Kansas, approximately 3.5 miles of 12-in. in Johnson and Lafayette counties, Missouri, and approximately 3 miles of 6-in. in Lincoln County, Kansas.

Oakford Gas Storage to Get New Facilities

New York State Natural Gas Corporation, Pittsburgh, Pennsylvania, and Texas Eastern Transmission Corporation, Shreveport, Louisiana, will add to facilities of their jointly-owned Oakford storage field in Westmoreland County, Pennsylvania. FPC has authorized installation of 6000 hp of additional compressor capacity at the existing Jeanette station and the transfer from Jeanette station of a 350 hp unit to a new location, the South Oakford station; the construction of 1 mile of 20-in. line, 3 miles of 6⅝-in. line, and 23 measuring stations at the Oakford storage project. These facilities will be constructed this year.

In 1957, the companies propose to construct 2.7 miles of 6⅝-in. line, 0.57 miles of 8⅝-in. line, and 20 measuring stations at the Oakford storage project.

Water Crossing Permits Asked

Applications have been made to the Army by two pipe line companies for permits to cross navigable waters in Texas and Louisiana.

Texas Eastern Transmission Corporation asks to lay 30-in. lines across Nueces River and Nueces Bay, Carancahua Bay, the Aransas and Mission rivers, Copano and Keller creeks, and Grullo Bayou. These waters are all in southwest Texas.

Interstate Oil Pipe Line Company would lay 12-in. lines across various bodies of water in Plaquemines Parish, Louisiana. One line would extend from Empire to the Gulf of Mexico; others would cross several bays, bayous, canals, etc.

Five Gas Line Applications Consolidated

Applications filed by five natural gas companies for the construction and operation of facilities estimated to cost a total of $191,805,503 have been consolidated by the Federal Power Commission for purpose of hearing, set for October 2.

Natural Gas Pipeline Company of America proposes to loop partially its existing main system between Beaver County, Oklahoma, and Joliet, Illinois, with 91.31 miles of 30-in. and 388.71 miles of 36-in. pipe.

Texas Illinois Natural Gas Pipeline Company has asked FPC permission to abandon the sale of natural gas for resale to all of its existing customers — other than its affiliate, Natural Gas Pipeline.

Chicago District Pipeline Company proposes a 50-mile, 36-in. loop to its existing line between Joliet and Chicago.

Pacific Northwest Pipeline Corporation plans to add 77,000 compressor hp to new and existing stations in the San Juan Basin, estimated cost set at $24,267,545.

Colorado Interstate Gas Company proposes to loop its present Fourway-Kit Carson with 791 miles of 16 to 30-in. line, with the addition of facilities, at a cost of $76,619,958.

Do you keep your fingers crossed

— every time you start one of your gas engine driven compressors? Many a starting air piping system has been blown into shrapnel by a lubricating oil vapor explosion. The possibility of this can be obviated by installing a Campbell Centrimpact separator. Price, $300.00, f.o.b. Long Beach, California. This is not a filter but a combination of centrifugal and impact design which throws out the finest mist particles and isolates them from the flow. We can state without fear of contradiction that CENTRIMPACT IS THE MOST EFFICIENT MIST EXTRACTOR EVER BUILT.

Send for our paper on "Explosions in Starting Air Piping Systems."

CAMPBELL
CENTRIMPACT

J. A. CAMPBELL COMPANY
Development and Manufacturing Engineers
645 E. Wardlow Road, LONG BEACH 7, Calif. GArfield 4-5092

Here it is-from **CINCH**

NEW VERTICAL HYDRAULIC PIPE BENDING MACHINE

It's the **only vertical hydraulic** pipe bender in the business . . . designed to save you time and money on the line. It's lighter . . . more compact . . . and faster. Since it's not overweight, overheight or overwidth it can be easily and quickly transported on float truck without removal of tracks.

Two sizes: 16" through 30"; 22" through 36". Already proven in field on 36" line over rough terrain in Georgia and North Carolina. You must see the new Cinch Vertical Hydraulic Pipe Bending Machine in action to appreciate its time-cutting, money-saving benefits.

It's a Cinch...Cinch Machines are used by the leading Pipeline Contractors.

CINCH
PIPELINE EQUIPMENT, Inc.

7020 Long Drive Phone: MI 5-2484
Houston 17, Texas

Canada's first

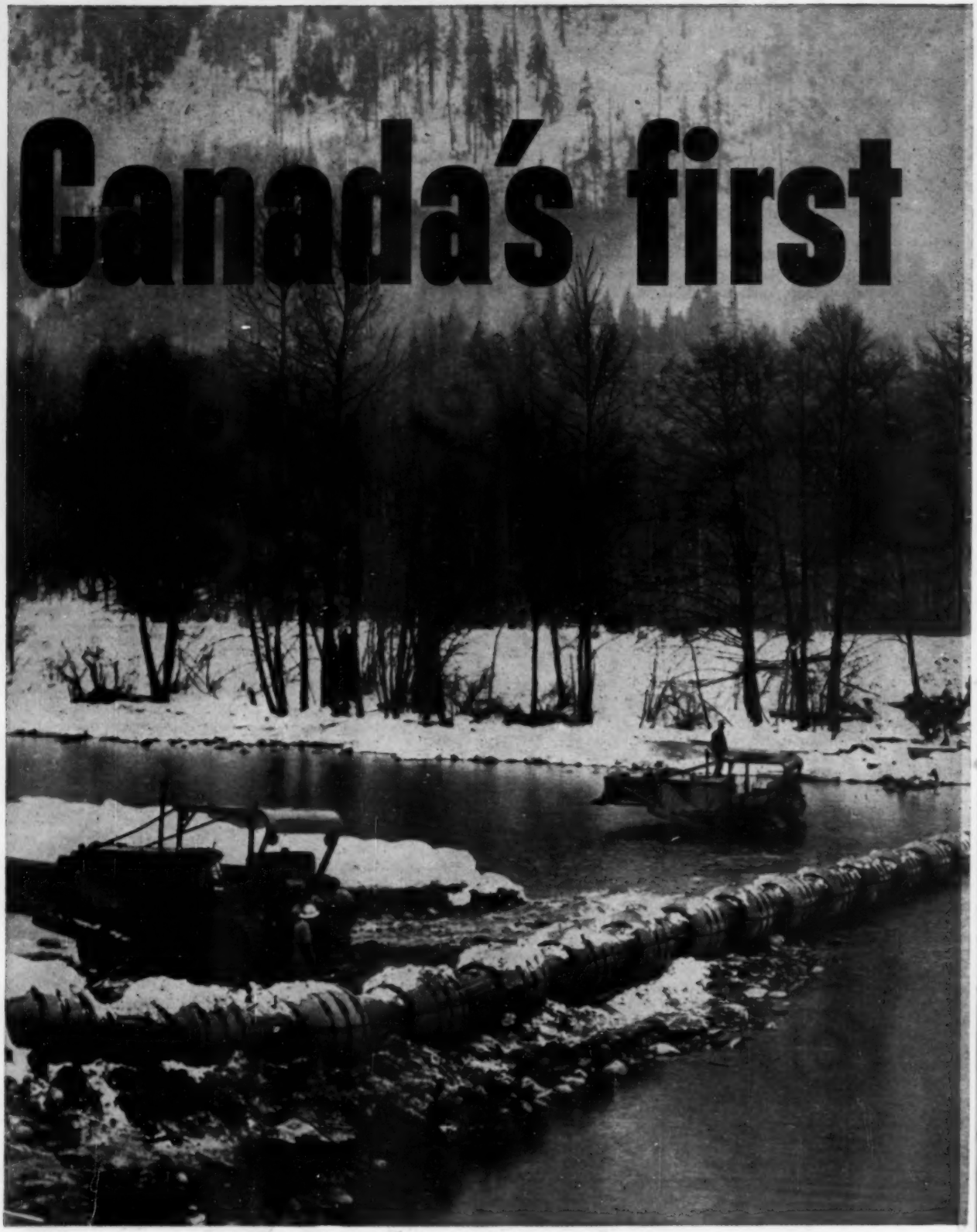


Photo shows the crossing of the Coquihalla River near Hope, British Columbia. The 30-inch diameter pipe is loaded with river weights and laid in a ditch beneath the river bed with eight feet of cover. Some of the river crossings, like this, were intentionally made during the winter when the water was at its lowest level.

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

"BIG INCH"

Kick-off for the line was at Huntington, B.C. Linkup with Pacific Northwest Pipelines is a short distance east of Vancouver. Westcoast has been authorized to draw gas from more than 42 million acres in the Peace River section in Alberta and British Columbia.

Westcoast Transmission Company, Limited, lays natural gas pipelines which will link British Columbia and New Mexico

TO tap the prolific gas resources of northeastern British Columbia and northwestern Alberta, Westcoast Transmission Company is now laying a 30-inch pipeline from the fields, almost due south to the international border near Vancouver. The line will provide natural gas for British Columbia and Pacific Coast States, the latter through a linkup with Pacific Northwest Pipeline Corporation which is currently completing a pipeline from New Mexico to the Northwest area.

Westcoast Transmission's 688-mile main line will have a maximum capacity of 660 million cubic feet per day and its completion will mark the first large-scale interchange of natural gas between western Canada's new and expanding fields and United States markets. Canadian Bechtel Limited are managers of engineering and construction for the project.

Marks first deliveries of 30-inch pipe from A. O. Smith Milwaukee plant

Approximately 22% of the 30-inch pipe used by Westcoast Transmission was shipped to the job from A. O. Smith's Milwaukee pipe mill. It was the first pipe of this size produced in the Milwaukee pipe mills' new facilities.

For almost 30 years . . .

A. O. Smith line pipe has always been manufactured to a high standard of quality . . . precisely controlled at every step of production. That's why A. O. Smith pipe, made and installed in 1928, is still in operation. That's why so much A. O. Smith pipe is in nearly every important high-pressure line.

Through research A.O. Smith *. . . a better way*

A.O.Smith
CORPORATION

TUBULAR PRODUCTS DIVISION
Milwaukee 1, Wisconsin

Chicago 4 • Dallas 2 • Los Angeles 17 • Midland 5, Texas • New Orleans 12
New York 17 • Pittsburgh 19 • San Francisco 4 • Seattle 1 • Tulsa 3 • Washington 6, D. C.
International Division: Milwaukee 1, Wisconsin

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

PIPE LINE PERSONALS

F. H. Warren

▸ **Fred H. Warren** ... former general superintendent of the eastern pipe line divisions of the Ohio Oil Company, named manager of the newly created operations planning department. He joined Ohio Oil in 1939 and in 1947 was named to his recent position. During World War II he was granted a leave of absence to serve with the Petroleum Administration for War as a petroleum transportation engineer.

▸ **E. D. Loughney** ... vice president and director of the British American Oil Company Limited, elected a director of Trans Mountain Oil Pipe Line Company. Previously vice president of Canadian Gulf Oil Company, Loughney succeeds **W. J. Wilkins** who resigned from the board.

▸ **Rolland Wages** ... named to fill newly created position of traffic supervisor in the purchasing department of Northern Natural Gas Company. With more than 12 years' experience in traffic supervision, he was previously with the Nebraska Railway Commission.

▸ **John L. Goforth** ... elected sales manager of Pipecote Service Corporation, replacing **J. C. Cooper,** resigned; **John R. Hurt** ... new secretary-treasurer, replacing **Barney F. Bedford,** also resigned.

▸ **Clyde O. Johnson** ... joined the administrative office of International Petroleum Company, Ltd., as transportation advisor. After serving Interstate Oil Pipeline Company from 1946 to 1952, he transferred to Standard Oil Company (N. J.) as engineer in the transportation coordination department.

▸ **Robert E. Hill** ... assistant manager of public and industrial relations for Cities Service Gas Company, transferred to a new Cities Service affiliate at New Orleans. With Cities Service since 1950 he will be in charge of industrial relations for Petroleum Chemicals, Inc., owned by Cities Service and Continental Oil Company.

▸ **Eliot D. Ernst** ... former assistant manager, crude oil purchasing, Pan American Production Company in Houston, Texas, named crude oil supply manager, supply and transportation department, American Oil in New York. He has been with American since 1947.

▸ **J. Ed McHale** ... named assistant manager of Magnolia Petroleum Company's crude oil purchases and sales department. **C. Fred Carl,** area representative at Wichita Falls, will be transferred to the company's general offices as administrative assistant of the department. **J. R. Lennon,** of the Midland district, will succeed Carl.

▸ **Roger D. Stanwood** ... elected vice president, gas supply of Transcontinental Gas Pipe Line Corporation. Previously with Tide Water Associated Oil Company, he joined Transco in 1951.

John C. Boehm ... became assistant superintendent of compressor stations for Transcontinental Gas Pipe Line Corporation, succeeding **Howard L. Cline** who became superintendent. Boehm has been with Transco since 1950.

▸ **William R. Remalia** was appointed manager of product supply in the supply and transportation department of American Oil Company in New York. He joined Standard Oil Company (Indiana) in 1938 and has served as manager of supply for Pan-Am Southern since 1951.

▸ **John W. Hawkins** ... named to newly-created position as manager of planning and development for Mid-Continent Pipe Line Company. He joined Mid-Continent this year from Service Pipe Line Company.

▸ **J. W. Futral Jr.** ... appointed a mechanical engineer for Southern Pacific Pipe Lines, Inc. He will be headquartered at Los Angeles, California.

▸ **J. L. Irvin** ... named general manager of the domestic pipe line department for the Gulf Oil Companies, and **Walter L. Shannon** ... made manager of domestic pipe line operations. Their offices will be in Houston, Texas.

Small Gas Turbine Introduced

GAS turbines for industrial applications rated in excess of 3500 hp have been used for some time. A new gas turbine in the 1000-hp class was recently introduced that is the first low power unit made available for pipe line pumping installations and compressor plants where high starting torque and variable operating speeds of the turbine are desired. The unit is a simple open cycle, dual shaft unit having a rating of 1130 bhp at 80F and 1000 ft elevation. Design is of the series flow type, having independent compressor and power turbine shafts.

The compressor and compressor turbine operate at 11,500 rpm. The power turbine has a nominal shaft speed of 6000 rpm, however output speeds of 1500 or 1800 rpm can be provided by built-in planetary gears. Thermal efficiency of unit, based upon lower heating values, is 15.1 per cent at full load and 13.4 and 11.0 per cent at three-quarters and one-half of full load respectively.

Complete turbine weighs approximately six tons and is readily portable. Normally supplied with one-piece base, the unit can be supplied with a two-piece base making it easily transportable where weight or size is a problem. Being overhung, the turbine wheels can be removed without disturbing the shaft or bearings. Heaviest component handled in normal maintenance weighs approximately 500 lb, eliminating the need for heavy cranes or hoists.

The small turbine designated as the Mark TA, will be manufactured and marketed in this country by Clark Bros. Co., one of the Dresser Industries, under an agreement with Ruston-Hornsby Ltd., Lincoln, England. More than 40 of the Mark TA turbines are operating at this time or will be placed in operation in the near future. ★ ★ ★

For the petroleum industry...

There's MORE

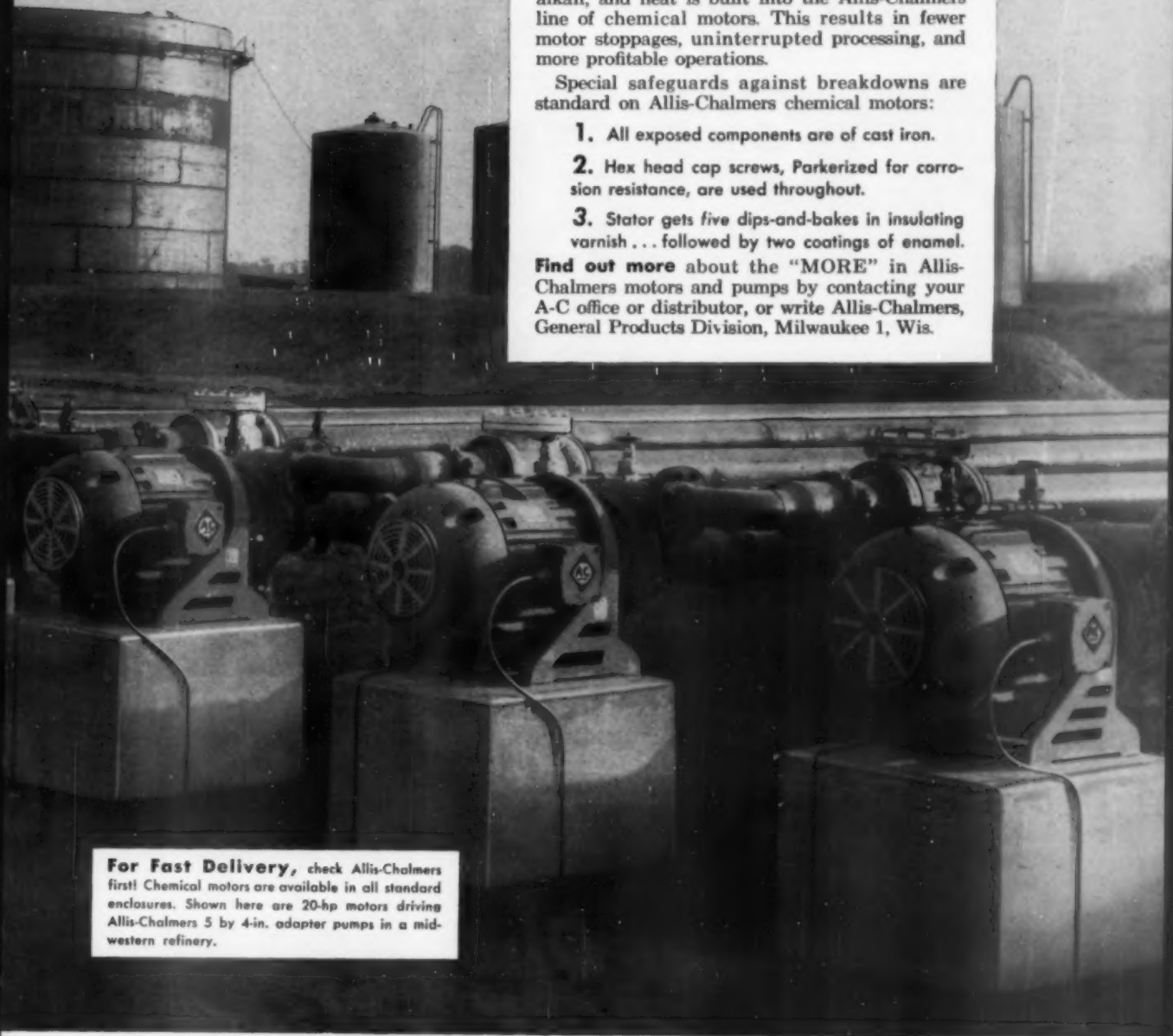
continuous processing with Allis-Chalmers chemical MOTORS and PUMPS

Maximum protection against moisture, acid, alkali, and heat is built into the Allis-Chalmers line of chemical motors. This results in fewer motor stoppages, uninterrupted processing, and more profitable operations.

Special safeguards against breakdowns are standard on Allis-Chalmers chemical motors:

1. All exposed components are of cast iron.
2. Hex head cap screws, Parkerized for corrosion resistance, are used throughout.
3. Stator gets *five* dips-and-bakes in insulating varnish . . . followed by two coatings of enamel.

Find out more about the "MORE" in Allis-Chalmers motors and pumps by contacting your A-C office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.



For Fast Delivery, check Allis-Chalmers first! Chemical motors are available in all standard enclosures. Shown here are 20-hp motors driving Allis-Chalmers 5 by 4-in. adapter pumps in a mid-western refinery.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5168

WITH THE

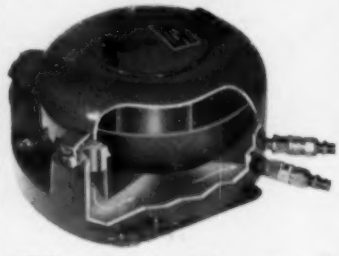
PIPE LINE CONTRACTORS

● **Dutton-Williams Brothers, Ltd., Pacific Building, Calgary, Alberta.** Has 120 miles of 30-in. gas line for *Westcoast Transmission Company, Ltd.*, between Taylor and Azouzetta Lake, British Columbia. Has 136 miles of 10-in. natural gas line between Lake Wabamum and Hinton, Alberta, for *North Canadian Oils, Ltd.* Has 45 miles of 10-in. line for *South Alberta Pipe Lines* between Etzikom and Medicine Hat, Alberta. Has a 30-in. crossing on the Pine River for *Westcoast Transmission Company*. Also has 65 miles of 8-in. line for *Cremona Pipe Lines* between Sundre and Calgary, Alberta. Has undetermined amount of 12 and 8-in. gathering line to lay for *Canadian Gulf Oil Company*, at Pincher Creek, Alberta. Also has 46 miles of 12 and 6-in. in the Rimbey-Jeffre field, Alberta, for *Rangeland Pipe Line*.

● **Eastern Pipeline Contractors, Mercantile Bank Building, Dallas, Texas.** Has 140 miles of 6, 8, and 10-in. laterals for *Pacific Northwest Pipeline Corporation* to Yakima and Wenatchee, Washington.

● **Engineers Limited, Inc., San Francisco, California.** Has 56 miles of 26-in. line for *Pacific Northwest Pipeline Corporation* between Goldendale and Stevenson, Washington.

WALKER COMBINATION PREHEATER AND HEATED CENTRIFUGE



Winter is Coming!

This new low-cost machine is the only economical device to make possible accurate B. S. & W. tests regardless of weather. Heat loss during test is negligible, even in coldest climate. Both 6 and 12 volt models. Install almost anywhere on gauger's car. Write for information and prices.

"Everything the Gauger needs from one dependable source."

W. L. Walker Co.

Phone: Diamond 3-8241

1009 South Main Tulsa, Okla.

● **O. R. Burden Construction Corporation, 6702 East Twenty-first Street, Tulsa, Oklahoma.** Has 110 miles of 8 and 10-in. line for *Missouri Public Service Company* between Boonville and Trenton, Missouri. Also has 150 miles of 8-in. line to take up and recondition for the *Ohio Oil Company* between Teutopolis and Martinsville, Illinois.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 252 miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has joint venture with H. C. Price on 121 miles of 30-in. natural gas line for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas-Louisiana state line near Eudora, Arkansas; work will be done in two spreads. Also has 162 miles of natural gas pipe line for *Tennessee Gas Transmission Company* in southern Louisiana. Has approximately 195 miles of natural gas pipe line work for *Texas Gas Transmission Corporation* in Mississippi, Arkansas and Southern Louisiana. Also has joint venture with H. C. Price on 121 miles of 22-in. gas line for *American Louisiana Pipe Line* from Defiance, Ohio, to Bridgeman, Michigan.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta.** Has 60 miles of 4 to 16-in. crude lines in Redwater and Simmons area of Alberta for *Imperial Oil Limited*. Has 109 miles of 12-in. crude line from Cromer, Manitoba, to Midale, Saskatchewan, for *Westspur Pipe Line Company*.

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 246 miles of 30-in. natural gas line from Hancock County, Indiana, to Slaughters, Kentucky, as part of a joint venture with Houston Contracting Company on 783 miles of 30-in. for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas state line near Eudora, Arkansas. Also has 82 miles of 26-in. line for *Tennessee Gas Transmission Company* near Chauncey, Ohio.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 90 miles of 14-in. to lay, 75 miles of 8-in. take-up and 30 miles of 4- and 5-in. take-up for *Sun Pipe Line Company* between Marcus Hook, Pennsylvania, and Plainfield, New Jersey.

● **Missouri Valley Dredging Company, 222 William Street, Omaha, Nebraska.** Has three major crossings on *Sun Pipe Line Company's* 109-mile new products line between Twin Oaks, Pennsylvania, and Newark, New Jersey; the crossings are on the Schuylkill, Delaware and Raritan rivers.

● **H. B. Zachry Company, P. O. Box 2570, San Antonio 6, Texas.** Has 217 miles of 22-in. natural gas line between Burley, Idaho, and Ontario, Oregon, for *Pacific Northwest Pipeline Corporation*.

● **Mannix, Ltd., 332 7th Avenue W., Calgary, Alberta.** Has 110 miles of 30-in. gas line at the south end of *Westcoast Transmission Company's* gas line from Peace River area, Alberta, to U. S.-Canadian border near Vancouver, British Columbia. Also has approximately 200 miles of 3 to 12-in. gathering line in the Pembina field for *Pembina Pipe Line, Ltd.* Has 90 miles of 34-in. gas line for *Trans-Canada Lines, Ltd.*, between Moose Jaw and Wolseley, Saskatchewan.

● **Williams-Austin Company, 3322 Grant Building, Pittsburgh 19, Pennsylvania.** Has 50 miles of 24-in. between Hardy County, West Virginia, and Greene County, Virginia, for *Atlantic Seaboard Corporation*. Has 37 miles of 26-in. loop lines for same company along Cobb-Rockville line, West Virginia. Has 17 miles of 30-in. line for *New York State Natural Gas Corporation* in Steuben County, New York.

● **Oklahoma Pipe Line Contractors, 6612 Hines Blvd., Dallas 20, Texas.** Has 327 miles of 18-in. line for *Plantation Pipe Line Company* between Baton Rouge, Louisiana, and Helena, Alabama. Has 74 miles of 6-in. for *Tennessee Gas Transmission Company* between the Brazos River near West Columbia, Texas, and Lavaca Bay.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston 19, Texas.** Has 400 miles of 24 to ¾-in. line for Spokane *Fuel and Gas Company* for natural gas distribution system within the city of Spokane, Washington.

● **Engineering-Construction Company, 407 First National Bldg., Tulsa, Oklahoma.** Has approximately 400 miles of ¾ through 12-in. distribution line for *Cascade Natural Gas Corporation* for several cities in Washington.

● **Latex Construction Company of Georgia, P. O. Box 184, Fond du Lac, Wisconsin.** Has 90 miles of 16 and 20-in. line between Oshkosh and Milwaukee, Wisconsin for *Michigan-Wisconsin Pipe Line Company*.

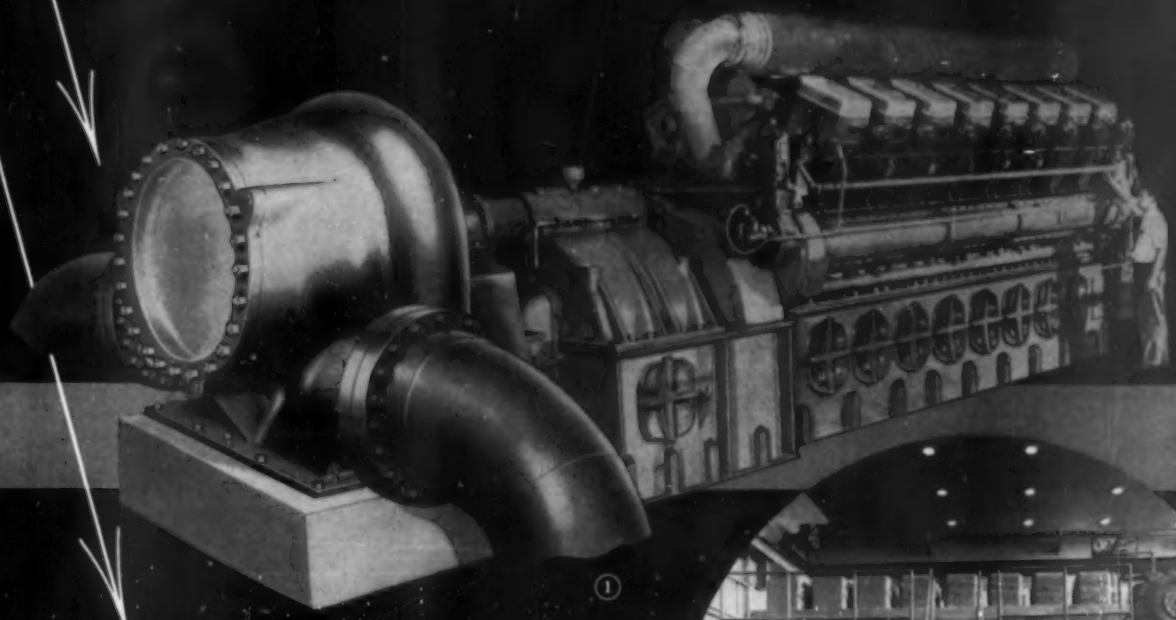
● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has contract for construction of a natural gas system, an extension and gathering lines for *Saskatchewan Power Corporation* in Saskatchewan; work consists of 42 miles of 4 to 10-in. line. Also has contract on natural gas line from Biggar to North Battleford and a natural gas transmission line from Dana to Humbolt, all in Saskatchewan, for the same company; this line consists of 34 miles of 8-in. and 53 miles of 6-in. pipe. Has 120 miles of 12-in. gas transmission line from Success to Moose Jaw, Saskatchewan, also for *Saskatchewan Power*.

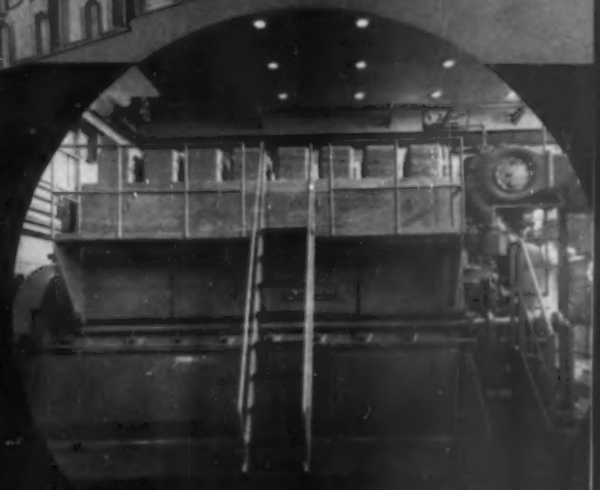
● **Banister Construction, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has contract for natural gas distribution system for *Saskatchewan Power Corporation* for the towns of Asquith, Biggar, Bruno, Cudworth, Humbolt, Perdue and Wakaw, Saskatchewan. Has contract for major extension of existing systems for the same company in four Saskatchewan towns.

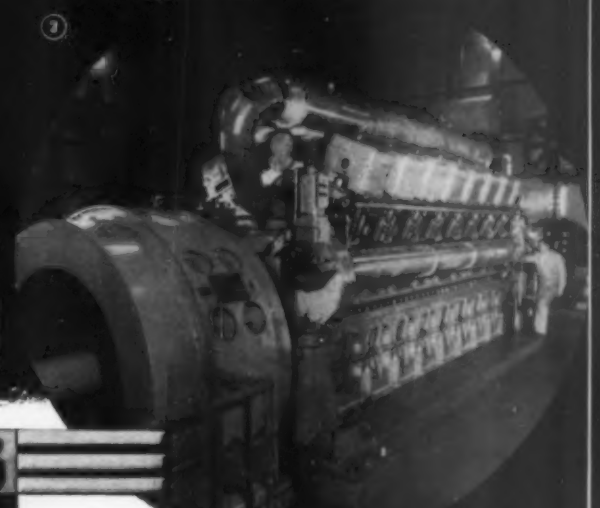
● **Wescan Pipeliners, Ltd., P. O. Box 879, Shaunavon, Saskatchewan, Canada.** Has 60 miles of 12-in. line for *South Saskatchewan Pipeline Company* between Swift Current and Dollard.

● **Gragg (Canada) Limited, 295 Kipling Avenue South, Toronto, Ontario.** Has various city distribution work in Toronto for the *Consumers Gas Company of Toronto*.

CUT COSTS on these 3 basic power jobs with NORDBERG *Supairthermal*® ENGINES...







① **for GAS COMPRESSOR DRIVE** Big savings in fuel costs on large capacity gas pipe lines and in refineries can be realized with the Nordberg *Supairthermal* engine gear set, driving a centrifugal gas compressor, for the simple reason that less fuel is required.

② **for PIPE LINE PUMPING** In pipe line pumping service, the trend is toward Nordberg four-cycle *Supairthermal* engine power . . . these engines produce *more* power in *less* space—substantially reducing installation and operating costs. What's more—the efficiency of these powerful engines turns low fuel consumption rates into *profit dollars* at the end of the line.

③ **for POWER GENERATION** Nordberg *Supairthermal* engine generating units supply reliable low cost electric power for many petroleum industry applications.

● Nordberg four-cycle *Supairthermal* engines are available in a full range of sizes from 535 to 5000 hp for Diesel, Duafuel® or Spark-Ignition Gas operation, including both In-line and "V" types. The *Supairthermal* principle of operation increases the engine's load-carrying ability at any given speed, over a wide speed range. This reserve power is like *"money in the bank"* when additional capacity is needed. We welcome your inquiry and the opportunity to assist you.

NORDBERG MFG. CO., Milwaukee, Wis.

NORDBERG

DIESEL • DUAFUEL® AND SPARK-FIRED GAS ENGINES

0555

© 1955, Nordberg Mfg. Co.

Preventing Fires While Repairing Lines

Tested procedures that Sohio Pipe Line Company has found most successful

W. J. Irwin
Safety Engineer,
Sohio Pipe Line Company,
St. Louis, Missouri

IT is most necessary that each member of a work crew knows how to prevent the ignition of vapors of a fuel supply, but, since that is a program in itself, I will not attempt to discuss ways and means of accomplishing this objective. In my personal opinion, it is a continuing process and cannot be accomplished by shotgun methods.

The best procedure, we have found, is to take to each workman in the field as much detail as we can obtain of the disastrous fire experiences that we and others have had, as soon as we can after we hear of the occurrence. We do not detract from or dress up the report. We stick to the facts as we are able to get them.

This has been a very important phase of our efforts to prevent fires and has proved very successful.

I would like to confine my remarks to the steps I feel are pertinent to the prevention of fire at work sites.

We have a safety manual that is issued to each maintenance foreman and available to each crew member. The interpretation of the procedures is a two-way proposition, from foremen to individual crew members and from the crew back to the foreman. When we are asked *why* a certain safety policy is in effect, it is an established policy that hedging is not done. If we have a logical reason, we give it. If it just seems like a good idea until something better comes along, we lay our cards on the table, and not so surprising, we get some better ideas from the crew.

Planning of a job is our first step. This includes answers to *why* the work is so scheduled. The day's schedule is usually given at the 5-min morning safety meeting held by most maintenance crews.

Some crews have a 15-min Monday morning meeting. They can have whichever they feel suits their needs best. Once they decide, they stick to either the 5-min daily or 15-min weekly. The 5-min daily safety session usually last 20 to 30 min, and the 15-min weekly usually takes 45 min to an hour.

Planning the Job

Planning of a job includes discussion of:

a. Job to be accomplished.
b. Profile of the line.
c. Manpower, equipment, and materials required.
d. A check-out of other operations that are affected — such as station operators, gagers, etc.

After arrival at the job site, job procedure instructions designate *work area* (150 ft out from leak or oil-soaked ground.) It is the duty of the foreman to see that:

1. No vehicles are in the work area (welding truck to be at least 100 ft from the bell hole after the area tests safe).
2. No welding until area tested safe, then all men advised that the area is safe and that work will proceed.
3. No smoking in work area — matches, lighters, etc., to be left in trucks outside work area.
4. Men suitably dressed — long sleeved shirts and body covered as much as possible.
5. Men in work area must have a job to do; if not, they are to move out of area.
6. Each man on job to be instructed and know what part he is to handle in the overall job being done.
7. Fire extinguishers — off truck and checked, windward side and manned.

Preparing the Area

In preparation of the area:

a. Bell holes should be sized larger than just sufficient — steps or sloping sides, if deep; life lines, with a man assigned to hold safe end of line.
b. Test area with explosimeter — if needle moves, do not work.
c. Remove oil-soaked ground from bell hole at least 5 ft back from edges of hole and cover with fresh dirt.
d. If emergency repair must be made, temporary clamps are used or a section removed and weld end couplings used.
e. Bell hole tested with burning rag by throwing into bell hole from a distance of 10 ft back.

Preparing the Line

In preparing the pipe line, make certain you:

a. Lower line pressure when temporary clamp is to be used.
b. Block out section to be worked — close valves, remove handwheels, tag valves, etc. Pumps are to be tagged and operators notified. If close to work site or to hold against pressure, block is accomplished by line blanks.
c. Locate vents to eliminate vacuum pockets and permit complete draining of line. Also locate them not closer than 10 ft of cut where a man is stationed to note vapor or oil accumulation in line.
d. When draining a pipe section by pumping around a valve or to a tank truck, the connections are

to be solid pipe connections. Do not permit draining into bell hole and then picking up with a pump.

e. Use bonding cables for protection against static electricity and cathodic rectifiers.

f. Use vapor packs — plumber plugs when putting on flanges, etc., or mud packs 18 to 24 in. in length, fire clay and not earth from area.

Portable pumps should have:

a. Shielded ignition.

b. Spark-arresting muffler.

c. Carburetor intake.

Tank trucks should be driven no closer than 100 ft of oil-soaked ground — we have been experimenting with plastic pipe for pump discharge.

Tapping and Plugging

In tapping and plugging machines:

a. Vent couplings are welded on while oil flow is maintained.

b. No welding is done until pressure is below 300 psi. (Up to 4-in. pipe, no pits are welded if deeper than .08 in. Above 4-in. pipe, no pits are welded if deeper than .10 in. Welders' judgment is final in all cases. If pit is too deep, patch is used.)

c. Use a small tapping machine to open line at vent couplings.

d. If a line is sectionalized with a plugging machine and must hold against a static pressure of 150 psi, use two spaced plugs and a vent in between to detect a leakage past the first plug.

Welding

When welding:

a. Machine should be 100 ft back from bell hole.

b. Ground connections must be by cable to weld site, not by piping through valves, flanges, etc.

c. Welder must have a helper in attendance (wearing safety glasses).

d. Welder and supervisor, leadman or gang pusher must test area before welding. A burning rag is then thrown into the bell from a point 10 ft from the bell hole.

e. Two men are to have fire extinguisher in hand and ready while welding is being done (safety glasses to be worn by the men manning the extinguishers).

f. Safety harness if bell hole is deep.

g. Periodic explosimeter tests should be made, especially if area is left for a time (lunch, to procure material, etc.).

h. In removing old section of pipe, torch cutting is not permitted on sections larger than 400 ft and then only after the section has been flashed from both ends.

i. No welding should be permitted on an empty line until the line is properly gas freed or sectionalized by mechanical stopples or mud packs.

In training employees in fire prevention and extinguishment:

a. Minimum theory should be included.

b. Practice:

1. At least one year, demonstrate on actual fires.
2. Practice checking and refilling extinguishers.

c. Show an occasional movie on oil fires, not for techniques, but to show magnitude of oil fires.

d. Keep all employees informed of experiences in other areas. This is a toughie; information is easy to pass on once we get it, but quite often things happen, and it is a long time before we learn about them. Recent occurrences are more impressive.

e. First aid training.

Acknowledgment

This paper was presented before the 43rd National Safety Congress, Chicago, Illinois. ★ ★ ★

Transcontinental to Boost Service In Carolinas

An application by Transcontinental Gas Pipe Line Corporation, of Houston, Texas, seeking authority to construct $8,550,000 facilities to boost by 50 per cent the amount of gas previously requested for the tidewater areas of North and South Carolina, has been accepted for filing, the Federal Power Commission announces.

The proposed added construction consists of 30.90 miles of 36-in. pipe line and 42.94 miles of 30-in. in Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, and Pennsylvania. These facilities would be constructed during 1957 and would raise the total cost of the entire project to $50,858,000.

Service Pipe Line Buys Pan-Am Southern System

The Service Pipe Line Company, a transporter of crude oil, has acquired the crude oil transportation facilities of the Pan-Am Southern Corporation, and assumed ownership today.

J. L. Burke, president of Service Pipe Line, said the acquisition was part of a plan announced last March by Standard Oil Company (Indiana) to consolidate a number of subsidiary companies engaged in similar functions.

Pan-Am Southern Corporation's crude oil pipe line system consists of about 285 miles of lines in southern Arkansas and northern Louisiana, and a gathering system in northwestern Louisiana consisting of 52 miles of lines. The latter is known as the Pine Island system and is connected to the Interstate Oil Pipe Line Company.

The southern Arkansas-Louisiana system delivers crude oil to the Pan-Am Southern refinery at El Dorado, Arkansas. It lies in Union, Columbia, and Ouchita counties of Arkansas, and Union and Claiborne parishes of Louisiana.

From Stanolind Oil and Gas Company, Service has purchased two more gathering systems in southern Louisiana. These are the Hackberry system, in Cameron Parish, and the Jennings system in Acadia Parish.

All of the Louisiana and Arkansas purchases will be added to Service Pipe Line's East Texas division. The Pan-Am Southern acquisition will be under the supervision of G. G. Moore, and will be a new district with headquarters at El Dorado. The southern Louisiana purchases also have been set up as a new district, with John A. Grant as the district superintendent at Beaumont, Texas.

Gas Company Operating Revenues Exceed $2½ Billion in 1955

Gas operating revenues of natural gas companies filing annual reports with the Federal Power Commission totaled $2,633,079,000 for the year 1955, and sales of natural gas by the companies amounted to 8.39 trillion cubic feet. One hundred eleven such companies were in operation during 1955, but mergers during the year reduced the number to 109 at the year's end.

Sales of natural gas and revenues from such sales reported by the natural gas pipe line companies for 1955 amounted to 6.73 trillion cubic feet and $1,780,177,000, respectively, representing increases of 8.0 per cent in sales and 16.2 per cent in revenues, over sales of 6.23 trillion cubic feet and revenues of $1,532,030,000 in 1954.

In keeping with the character of the companies, 80.3 per cent of their 1955 gas sales — 5.40 trillion cubic feet — were made to other natural gas companies for resale. Revenues from such sales, $1,495,-209,000, were equal to 84.0 per cent of total revenues from all gas sales.

Corrosion Program Highlights NACE October Meeting

Symposia on corrosion problems in the pipe line industry and underground generally are on the program of the October 23-26 San Antonio, Texas, meeting of South Central Region, National Association of Corrosion Engineers.

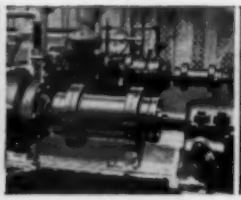
Six NACE technical committees investigating underground corrosion problems also will meet.

Four technical papers on inhibitors, cathodic protection, and other aspects of pipe line corrosion are listed for the symposium on Corrosion in the Pipe Line Industry. Loyd B. Nelson, Shell Pipe Line Company, and A. L. Stegner, Tennessee Gas Transmission Company, are respectively chairman and vice chairman.

The Cathodic Protection symposium, with Marshall E. Parker, Cormit Engineering Company, as chairman, will have papers on the copper-copper sulfate electrode, rectifier efficiency, high-silicon anodes, and cathodic protection of oil well casings.

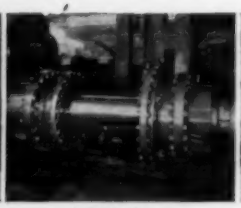
Committees are scheduled to discuss minimum current requirements, standardization of procedures for measuring pipe line coating conductance, internal corrosion of product pipe lines, prefabricated plastic film for pipe line coatings, and other matters.

Paper Industry

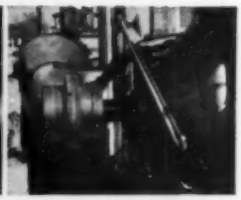


Oil and Gas Industry

Marine Industry

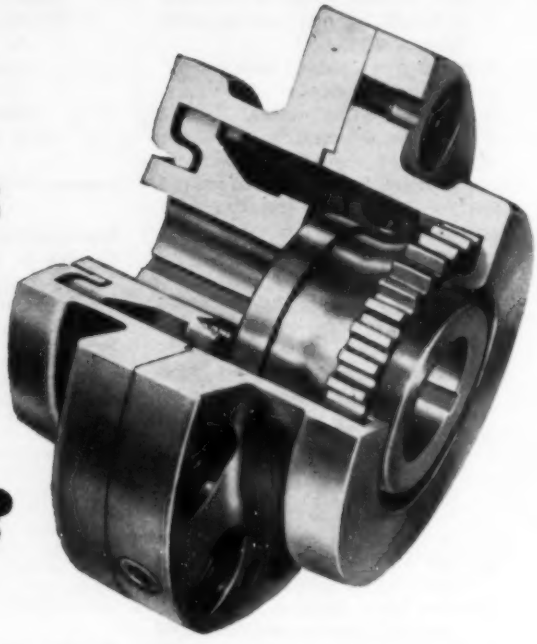


Steel Industry



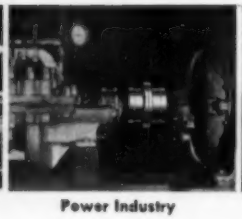
Oil and Gas Industry

Why have Fast's Couplings always been the leader in the rugged oil and gas industry?



Why are they used so widely to couple machinery in Power Generation, Pulp and Paper, Oil and Gas, Marine Propulsion and Auxiliaries, Steel and industry in general?

Steel Industry



Power Industry

Lumber Industry

Chemical Industry

Paper Industry

Fast's Couplings are standard equipment with more machinery manufacturers than any shaft coupling on the American market. Many Fast's Couplings in use over 30 years still show no signs of wear when disassembled! That's the answer: they're reliable, they're *mechanically* flexible, they don't wear. They have no parts subject to repeated bending, tension or compression. There is no metal-to-metal contact, because of *positive lubrication.* Regardless of your field — no matter whether your connected machine is driven by steam turbine or electric motor, low-speed diesel or high-speed gas turbine . . . Koppers has the perfect, low-cost solution to your shaft coupling problem.

For free catalog write to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3209 Scott St., Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Industrial Gas Cleaning Apparatus, Gas Apparatus.

Engineered Products Sold with Service

KOPPERS

THE ORIGINAL

FAST'S Couplings

Cut maintenance costs. . . increase pipe life

with proven performance . . .

On job after job, pipe line men rely on these Johns-Manville Asbestos Pipe Protection Materials to fight pipe line corrosion:

Transhield® Asbestos Felt This low-cost pipe line protecting wrapper is specially designed to increase pipe life under average soil conditions. It is reinforced with continuous glass yarns, parallel spaced on ¼" centers to give tear-free application strength. Made of coal-tar saturated asbestos, it acts as a lasting barrier to shield pipe line enamels from earth loads and soil stresses.

#15 Asbestos Pipe Line Felt—A heavy-duty material particularly suitable for severe soil conditions or where a heavier material than J-M Transhield is desired. Provides long life, toughness, flexibility, resistance to rot, decay, cracking, and impact. J-M #15 Asbestos Felt now protects more than 100,000 miles of oil and gas pipe lines. Widths 2" to 36". Rolls any length desired.

For further information about Johns-Manville Products for Pipe Line Protection, write to Johns-Manville, Box 14, New York 16, N. Y.; in Canada, Port Credit, Ontario

Johns-Manville **PRODUCTS FOR PIPE LINE PROTECTION**

Here the new 75-drawbar-hp HD-11, (25,470 lb as illustrated), teamed with another Allis-Chalmers crawler, starts up the mountain from the "shoefly" pulling a pipe truck. Distance up the slope was 1,175 ft. A man could not climb more than 200 feet of the entire trip.

Allis-Chalmers Crawler Tractors Whip Rocks and Razorbacks on "Wilderness Road" Pipe Line

H. B. Ranier Company pushes 12-inch line through Kentucky's roughest terrain

Nicknamed "Wilderness Road," the 31 miles of 12-inch gas line between Osborn Gap, Virginia, and Maytown, Kentucky, was one of the toughest pipe jobs ever handled by H. B. Ranier Construction Company, Prestonsburg, Kentucky.

Ranier's spread, headed by nine Allis-Chalmers dozer and side boom tractors, gouged the right-of-way out of steep razor-back slopes that were 80 percent rock. Often the rock cliff terrain was so steep that one crawler was used to hold another with a winch line for dozing out the right-of-way or lowering in the pipe.

Allis-Chalmers Crawler Ranier's Personal "Car"

On much of the line, a tractor was the only vehicle used — transporting men and supplies in addition to regular work. In fact, contractor Ranier used one of his Allis-Chalmers crawlers to drive up and down the line on inspection trips.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

This powerful, new Allis-Chalmers HD-16 with angledozer is holding a backhoe with a winch as it works down a steep grade. Note the steep right-of-way in background. HD-16 has 125 drawbar hp, weighs 37,677 lb, as illustrated.

An anchor line for safety is hooked on to this HD-16 as it dozes rock out of the trench. This is the type of material the tractors dozed out on most of the job.

Sure-footed Allis-Chalmers side boom tractors like this machine handled pipe sections for dope machines and lowered pipe into trench.

Tractors Stand Up

Ranier stated, "Allis-Chalmers tractors have many advantages, but the biggest is the way they hang in there day after day without downtime. The fact that these tractors stood up so well helped us get faster pipe footage in spite of the terrain and the weather."

Allis-Chalmers Crawlers Get Operators' Vote

Ranier's tractor operators, to a man, preferred Allis-Chalmers machines. One said, "Those 'HD's' will climb where other makes have to be winched up a steep grade. On these hills, it's the only machine that'll pull its own weight and something along with it."

Make Your Own Test

Find out for yourself why pipeliners like H. B. Ranier equip their spreads with advanced-design Allis-Chalmers crawlers. Check any model from the big HD-21, through the HD-16 and HD-11 to the versatile HD-6 — they're all designed to give you faster pipe footage at less cost.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION
MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

Horsepower Ratings for "B" Section V-Belts

STANDARD QUALITY

Belt speed (ft per min.)	Equivalent diameter (d_e)												
	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0 and over
200	.37	.38	.40	.42	.43	.44	.46	.47	.48	.49	.50	.50	.51
400	.64	.67	.70	.73	.76	.79	.81	.84	.86	.88	.89	.91	.93
600	.87	.92	.97	1.02	1.06	1.10	1.14	1.17	1.20	1.23	1.26	1.28	1.31
800	1.08	1.15	1.22	1.28	1.33	1.39	1.43	1.48	1.52	1.56	1.60	1.63	1.67
1000	1.27	1.36	1.44	1.52	1.59	1.65	1.72	1.77	1.82	1.87	1.92	1.96	2.01
1200	1.45	1.56	1.65	1.74	1.83	1.91	1.98	2.05	2.11	2.17	2.23	2.28	2.33
1400	1.61	1.73	1.85	1.95	2.05	2.14	2.23	2.31	2.38	2.45	2.51	2.58	2.63
1600	1.75	1.89	2.02	2.15	2.26	2.36	2.46	2.55	2.63	2.71	2.79	2.86	2.92
1800	1.88	2.04	2.19	2.32	2.45	2.57	2.67	2.78	2.87	2.96	3.04	3.12	3.20
2000	1.99	2.17	2.33	2.48	2.62	2.75	2.87	2.99	3.09	3.19	3.29	3.37	3.46
2200	2.09	2.28	2.46	2.63	2.78	2.93	3.06	3.18	3.30	3.41	3.51	3.61	3.70
2400	2.16	2.38	2.57	2.76	2.92	3.08	3.22	3.36	3.49	3.61	3.72	3.82	3.92
2600	2.22	2.46	2.67	2.86	3.05	3.22	3.37	3.52	3.66	3.79	3.91	4.02	4.13
2800	2.27	2.51	2.74	2.96	3.15	3.33	3.50	3.66	3.81	3.95	4.08	4.20	4.32
3000	2.29	2.55	2.80	3.03	3.24	3.43	3.61	3.78	3.94	4.09	4.23	4.36	4.49
3200	2.29	2.57	2.84	3.08	3.30	3.51	3.70	3.89	4.05	4.21	4.36	4.50	4.63
3400	2.27	2.57	2.85	3.11	3.35	3.57	3.77	3.97	4.15	4.31	4.47	4.62	4.76
3600	2.23	2.55	2.84	3.12	3.37	3.60	3.82	4.02	4.21	4.39	4.56	4.72	4.87
3800	2.16	2.50	2.81	3.10	3.37	3.61	3.85	4.06	4.26	4.45	4.63	4.79	4.95
4000	2.08	2.43	2.76	3.06	3.34	3.60	3.85	4.07	4.28	4.48	4.67	4.84	5.01
4200	1.96	2.34	2.68	3.00	3.29	3.57	3.82	4.06	4.28	4.49	4.68	4.87	5.04
4400	1.83	2.22	2.58	2.91	3.22	3.51	3.77	4.02	4.25	4.47	4.68	4.87	5.05
4600	1.66	2.07	2.44	2.79	3.11	3.41	3.69	3.95	4.20	4.42	4.64	4.84	5.03
4800	1.46	1.89	2.29	2.65	2.98	3.30	3.59	3.86	4.11	4.35	4.57	4.78	4.98
5000	1.24	1.69	2.10	2.47	2.82	3.15	3.45	3.73	4.00	4.25	4.48	4.70	4.90
5200	.99	1.45	1.88	2.27	2.63	2.97	3.29	3.58	3.86	4.11	4.36	4.58	4.80
5400	.70	1.19	1.63	2.04	2.41	2.77	3.09	3.40	3.68	3.95	4.20	4.44	4.66
5600	.39	.89	1.35	1.77	2.16	2.52	3.86	3.18	3.48	3.75	4.01	4.26	4.49
5800	.04	.56	1.03	1.47	1.88	2.25	2.60	2.93	3.24	3.52	3.79	4.05	4.29
6000	—	.19	.68	1.13	1.55	1.94	2.31	2.65	2.96	3.26	3.54	3.80	4.05

PREMIUM QUALITY

200	.49	.51	.54	.56	.58	.60	.61	.63	.65	.66	.67	.68	.70
400	.84	.89	.94	.98	1.02	1.06	1.09	1.13	1.16	1.18	1.21	1.24	1.26
600	1.15	1.23	1.30	1.36	1.42	1.48	1.53	1.57	1.62	1.66	1.70	1.74	1.77
800	1.43	1.53	1.62	1.71	1.79	1.86	1.93	1.99	2.05	2.11	2.16	2.21	2.26
1000	1.68	1.81	1.92	2.03	2.13	2.22	2.31	2.39	2.46	2.53	2.60	2.66	2.72
1200	1.91	2.06	2.20	2.33	2.45	2.56	2.66	2.76	2.85	2.93	3.01	3.09	3.16
1400	2.12	2.30	2.46	2.61	2.75	2.88	3.00	3.11	3.22	3.32	3.41	3.50	3.58
1600	2.31	2.52	2.70	2.87	3.03	3.18	3.32	3.45	3.57	3.68	3.78	3.88	3.98
1800	2.49	2.72	2.93	3.12	3.30	3.46	3.62	3.76	3.90	4.02	4.14	4.26	4.36
2000	2.64	2.90	3.13	3.34	3.54	3.73	3.90	4.06	4.21	4.35	4.48	4.61	4.72
2200	2.78	3.06	3.32	3.55	3.77	3.98	4.17	4.34	4.51	4.66	4.81	4.94	5.07
2400	2.90	3.20	3.48	3.74	3.98	4.20	4.41	4.60	4.78	4.95	5.11	5.26	5.40
2600	3.00	3.33	3.63	3.91	4.17	4.41	4.63	4.84	5.04	5.22	5.39	5.55	5.70
2800	3.08	3.43	3.76	4.06	4.34	4.60	4.84	5.06	5.27	5.47	5.65	5.83	5.99
3000	3.14	3.52	3.86	4.19	4.49	4.76	5.02	5.26	5.49	5.70	5.90	6.08	6.26
3200	3.17	3.58	3.95	4.29	4.61	4.91	5.18	5.44	5.68	5.90	6.12	6.32	6.50
3400	3.19	3.62	4.01	4.38	4.72	5.03	5.32	5.60	5.85	6.09	6.31	6.53	6.73
3600	3.18	3.63	4.05	4.44	4.80	5.13	5.44	5.73	6.00	6.25	6.49	6.71	6.92
3800	3.15	3.63	4.07	4.48	4.85	5.21	5.53	5.84	6.12	6.39	6.64	6.88	7.10
4000	3.09	3.59	4.06	4.49	4.89	5.26	5.60	5.92	6.22	6.50	6.77	7.02	7.25
4200	3.00	3.54	4.02	4.48	4.89	5.28	5.64	5.98	6.29	6.59	6.87	7.13	7.37
4400	2.90	3.45	3.97	4.44	4.88	5.28	5.66	6.01	6.34	6.65	6.94	7.22	7.48
4600	2.75	3.34	3.87	4.37	4.82	5.25	5.64	6.01	6.36	6.68	6.99	7.27	7.54
4800	2.59	3.19	3.75	4.27	4.75	5.19	5.60	5.99	6.35	6.68	7.00	7.30	7.58
5000	2.39	3.02	3.60	4.14	4.64	5.10	5.53	5.93	6.31	6.66	6.99	7.30	7.59
5200	2.16	2.82	3.43	3.98	4.50	4.98	5.43	5.85	6.24	6.60	6.95	7.27	7.57
5400	1.90	2.59	3.21	3.79	4.33	4.83	5.29	5.73	6.13	6.51	6.87	7.21	7.52
5600	1.61	2.32	2.97	3.57	4.13	4.65	5.13	5.58	6.00	6.39	6.76	7.11	7.44
5800	1.28	2.02	2.69	3.32	3.89	4.43	4.93	5.39	5.83	6.24	6.62	6.98	7.32
6000	.92	1.68	2.38	3.03	3.62	4.18	4.69	5.17	5.62	6.05	6.44	6.82	7.17

By Permission of The Multiple V-Belt Drive & Mechanical Power Transmission Association and The Rubber Manufacturers Association.

Notes: 1. Some of the smaller d_e values shown above are obtainable only with sheave diameters smaller than the minimum recommended in Table 1. Ratings for such small equivalent diameters are given in case it is necessary to use diameters smaller than the recommended minimum.

2. Belt speed is figured using the pitch diameter and R.P.M. of one of the sheaves on the drive.

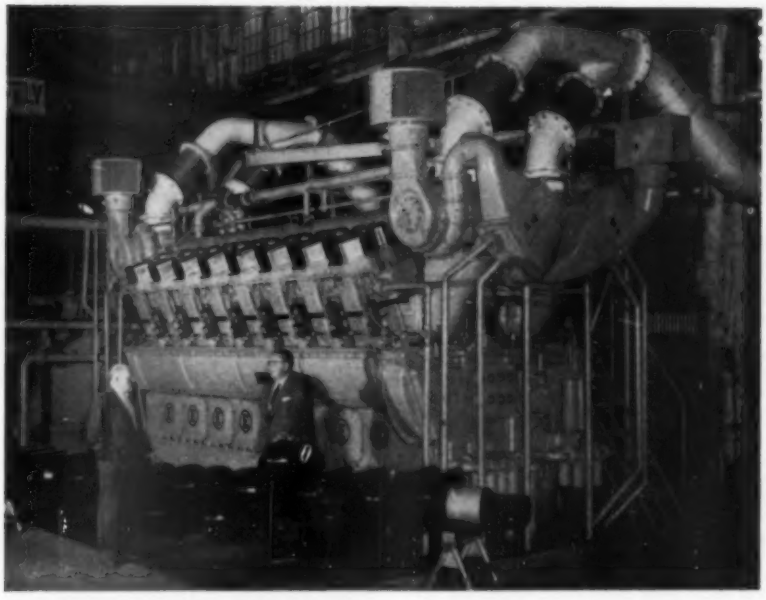
3. If belt speeds are over 5000 feet per minute the sheaves may require special construction or special material. They may also require dynamic balancing. Such applications should be referred to the manufacturer.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

NEW Pipe Line Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers



(81) 16-Cylinder RV Diesel Engine. The RV-16, prototype of a new line of industrial diesel engines has been completed by Enterprise Engine & Machinery.

Already sold to the government of Saudi Arabia, the new engine this month is completing dynamometer tests that verify its rating of 7700 hp at 400 rpm. By far the biggest engine Enterprise has built — and the company's first V-type engine — the RV-16 is still small in size by industrial diesel standards.

Enterprise Engine Machinery Company, Division of General Metals Corporation.

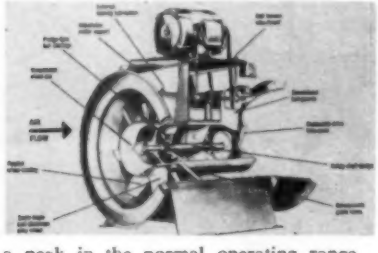
(82) Shovel and Crawler Crane. A ¾-yard shovel and 18-ton crawler crane has been announced by Marion Power Shovel.

It will be known as the 35-M and will be offered both with crawler and truck mountings. The truck crane will be known as the 35-MR and is rated at 25 tons.

Marion Power Shovel Company.

(83) Airfoil-Type Blading. The high efficiency of airfoil-type blading — already proved in centrifugal-type fans — has been extended to the Axiflo® fan line by the Sturtevant Division of Westinghouse.

Designated as Series 300, the improved Axiflo fans offer a non-overloading horsepower characteristic engineered to reach



a peak in the normal operating range, allowing greater air handling capacity and eliminating need for oversize motors, often required with conventional axial-flow types.

Sturtevant Division Westinghouse Electric Corporation.

(84) "Latrobe" Clamp. Fullman manufacturing has developed a type of pipe or conduit clamp known as the "Latrobe."

This clamp, made of high quality malleable iron, cadmium plated to prevent rust, has double bite of case-hardened tool steel. The safety bite is V-shaped to give a double bite into the steel frame to which it is attached. Clamp is made in two models — one for right angle support and one for parallel support.

Fullman Manufacturing Company.

(85) Low-Power Replacement Line. The G-Line, an economical single wire surface wave transmission line assembly designed to eliminate coaxial transmission line and waveguide in low-power microwave and television broadcasting is announced by Prodelin.

Designed for high efficiency operation at frequencies from 1700 to 2400 meg, the G-Line assembly consists of a modified copper wire coupled at each end with identical RF field transformers (launcher and collector).

Prodelin, Inc.

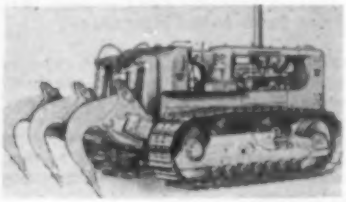
(86) Self-Disposing Liner. A new protecting coating product with a film-type, self-dispoing liner has been announced by Tapecoat.

Known as Tapecoat-SP, this liner is disposed of automatically in the torching application process.

Tapecoat Company.

(87) Tractor-Mounted Ripper. A tractor-mounted ripper designed specifically for use with the Caterpillar D9 Tractor has been announced by Caterpillar Tractor and will be called the No. 9 Ripper.

Complete ripper consists of two mounting brackets, two hydraulic cylinders, one



beam assembly, and three teeth. It weighs 10,830 lb. The ripper is used primarily to break up hard materials for subsequent scraper loading.

Caterpillar Tractor Company.

(88) Direct-Reading Digital Indicator. Fischer & Porter has developed a direct-reading digital indicator designed primarily for use with the company's turbine flow-meters.

Unit features a completely digital system, operating from the frequency output of the turbine meter, which takes full advantage of the remarkable linearity and repeatability inherent in the turbine meter primary.

Fischer & Porter Company.

(89) Iron-Powder, Low-Hydrogen Electrode. Air Reduction Sales has announced an electrode, designated as Airco Easyarc 328, for all-position welding of mild and low-alloy steels.

It is of the low-hydrogen type with iron powder added to the coating for high welding speeds.

Air Reduction Sales Company, a division of Air Reduction Company, Inc.

(90) Hydraulic Backhoe. A TerraTrac backhoe, designed and built exclusively for heavy-duty use on TerraTrac crawler

tractors, is announced by American Tractor.

One of the outstanding features claimed by the manufacturer is a full 180 deg boom-swing with hydraulic foot-pedal control, which is said to speed up cycle-time and greatly simplify operation, because it leaves the operator's hands free to maneuver the boom and bucket while swinging.

American Tractor Corporation.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(91) Propeller Fans. A revised catalog covering its line of propeller fans has been published by Hartzell Propeller Fan.

New fan sizes not shown in the previous edition as well as revised air deliveries, specifications, performance data, and dimensional drawings on the entire line are included.

Hartzell Propeller Fan Company, division of Castle Hills Corporation.

(92) Pneumatic Controllers. A 32-page bulletin describing Fisher Governor's pneumatic level controler, "Level-Trol," has been made available. Bulletin describes the principle of operation of the displacement-type float, as well as illustrates the construction available for many applications.

Fisher Governor Company.

(93) Synchronous Motors. Construction features of Allis-Chalmers large end-shield bearing synchronous motors are described in new literature released by the company.

The motors are said to meet the growing demand for a high degree of protection, combined with maximum accessibility for a variety of direct-connected or geared applications to drives for centrifugal blowers, compressors and fans, centrifugal pumps, etc.

Allis-Chalmers Manufacturing Company.

(94) Centrifugal Process Pumps. A 12-page, illustrated circular on its line of standard centrifugal process pumps has been released by Dean Brothers Pumps.

These pumps range in capacity from 10 gpm to 7000 gpm, liquid temperature from minus 250 F to plus 850 F, and working pressure from 30 in. of vacuum to 400 psig.

Dean Brothers Pumps, Inc.

(95) Gearmotors. Featuring the latest design improvements in gearmotors and embodying 60 illustrations in multicolor, a bulletin is now available presenting the various types of U. S. Syncrogear motors.

This 16-page bulletin shows comparative advantages of gearmotors and lists ratings from ½ to 30 hp with gear ratios as high 10:1.

U. S. Electrical Motors, Inc.

(96) Aluminum Alloys and Mill Products. A reference handbook on aluminum has been made available by Alcoa.

The 176-page book presents data on aluminum alloys and mill products in an easy-to-read tabular form, with little text.

Aluminum Company of America.

(97) Interlocked Armor Cable. A booklet on interlocked armor cable has been issued by General Electric.

This publication covers interlocked armor cable that is designed specifically for primary and secondary feeders in industrial power distribution systems and for generator leads, station auxiliaries, and station control cables in electric power stations.

General Electric Company.

(98) Nickel Cadium Storage Batteries. Two bulletins describe the long-lived Nicad pocket plate nickel cadmium storage batteries.

One bulletin covers control and standby batteries for switchgear, standby power, and emergency lighting. The other describes batteries for starting heavy-duty gas, gasoline, and diesel engines, operating fire pumps, standby generators, and remote power sources.

Nickel Cadmium Battery Corporation.

(99) Diesel Engines. Alco Products has announced publication of a 14-page bulletin on the company's new "family" of diesel engines — the 251 series — available in ratings from 550 to 2400 hp.

The two-color bulletin illustrates the engine series, which includes the 6-cyl, in-line model and the 12 and 16-cyl, V-type engines.

Alco Products, Inc.

(100) Cushioned Automatic Valves. "It's easier to open or close a Golden-Anderson valve than to drive a car with power steering" is the title of an illustrated bulletin published by Golden-Anderson Valve Specialty.

Reasons for the claim made by the title are thoroughly explained. Additional features of Golden-Anderson Cushioned Automatic Valves are also covered, plus a brief resume of 11 of the firm's complete line of specialty valves in sizes from 2 in. to 36 in.

Golden-Anderson Valve Specialty Company.

(101) Flowmeter. A four-page, two-color catalog describing the Laub Electro-Caloric Flowmeter has been released by Industrial Development Laboratories.

A cutaway view clearly illustrates the construction of the smooth-bore flow cell while a simple diagram effectively shows the principles of operation.

Industrial Development Laboratories, Inc.

(102) Motor Scraper. Allis-Chalmers pictorially tells about its TS-260 Motor Scraper in a 16-page, two-color catalog now available.

Catalog also includes many photographs showing engine, power train, steering, braking, and other components.

Allis-Chalmers Manufacturing Company.

(103) Services and Facilities. To enable executives, engineers, and others in industry and government to evaluate its capabilities, a 72-page illustrated bulletin covering its services and facilities has been published by Electrical Testing Laboratories.

Bulletin covers typical measurements and determinations made on hundreds of products and materials. In addition, it catalogs laboratory equipment available for limitless assignments in the fields of testing, applied research, and engineering analysis.

Electrical Testing Laboratories, Inc.

(104) Welding Equipment. Modern Engineering has announced the 1956 revisions of its general welding catalog.

Covered is its complete line of oxy-acetylene welding and cutting torches, machine cutting torches, regulators, pressure gages, hose connections, couplings, and safety equipment.

Modern Engineering Company.

(105) Gear-Type Flexible Couplings. A catalog covering Ajax Series D-100 standard, floating shaft and mill motor-type Dihedral Couplings has been published by Ajax Flexible Coupling.

Series D-100 Couplings are designed to handle angular and offset misalignment up to a total of 12 deg.

Ajax Flexible Coupling Company, Inc.

(106) Diesel Crawler Tractor. A series of assembly and parts photographs are used in a 16-page, two-color Allis-Chalmers catalog to illustrate the company's 75-hp HD-11 diesel-powered crawler tractor.

Catalog also contains a two-page spread devoted to the line of equipment matched to the HD-11.

Allis-Chalmers Manufacturing Company.

(107) Petroleum Gaging Equipment. W. H. Curtin has released an illustrated catalog on petroleum gaging equipment.

It lists all types of centrifuges, replacement parts and accessories — all the equipment essential for gaging petroleum and its by-products.

W. H. Curtin & Company.

(108) Floating-Roof Storage Tanks. A catalog and data book on the patented "Tubeseal" System for floating-roof storage tanks has been published by Hammond Iron Works.

Illustrated catalog describes the design and construction of the improved Hammond Tubeseal — the only floating-roof seal that completely eliminates every space between seal and product, according to the manufacturer.

Hammond Iron Works.

Tomorrow's Tools – Today!

POWER-PAK CHARGES

mean cleaner, karrotfree koneshot PERFORATIONS

This is the debris not left to clog perforations by Power-Pak Karrotfree Koneshot.

Lane-Wells designed and perfected Karrotfree Koneshot Perforating to give the industry cleaner perforations without loss of penetration. Power-Pak Koneshot charge design gives you all the advantages of Karrotfree perforating plus, on actual test, deeper clean, debris-free perforations.

Power-Pak perforating, an original exclusive Lane-Wells development, is available only through Lane-Wells Branches. For consistently better perforating results, call Lane-Wells and "get the job done right."

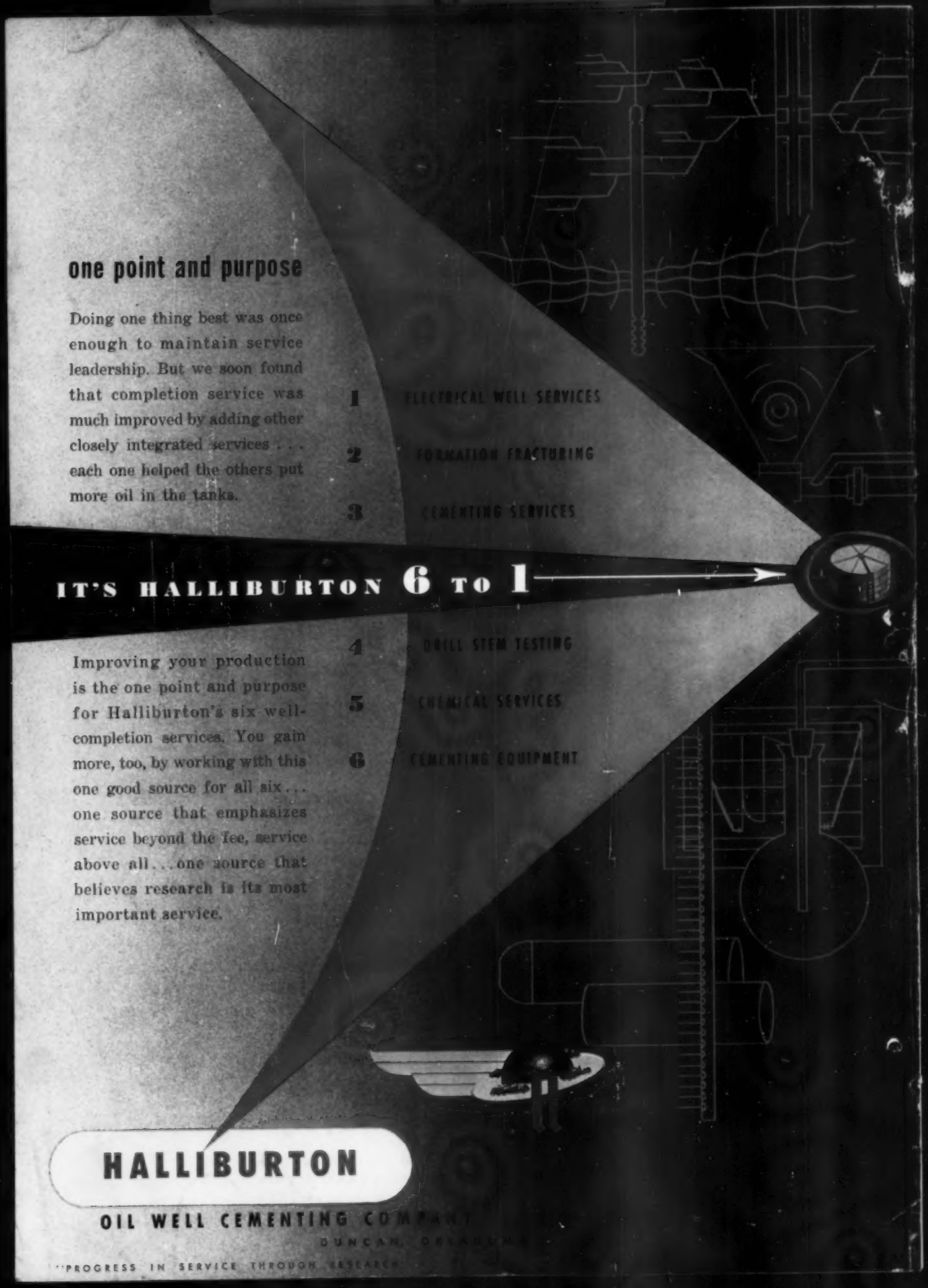
24-SHOT UNITS

40-SHOT UNITS

LANE WELLS COMPANY

General Offices, Export Office and Plant
5610 So. Soto St., Los Angeles 58, California

Sales and Service Headquarters | 511 West Alabama Street, Houston, Texas
Mail Address: P.O. Box 1664, Houston 1, Texas


one point and purpose
Doing one thing best was once enough to maintain service leadership. But we soon found that completion service was much improved by adding other closely integrated services . . . each one helped the others put more oil in the tanks.
1 ELECTRICAL WELL SERVICES
2 FORMATION FRACTURING
3 CEMENTING SERVICES
IT'S HALLIBURTON 6 TO 1
4 DRILL STEM TESTING
5 CHEMICAL SERVICES
6 CEMENTING EQUIPMENT
Improving your production is the one point and purpose for Halliburton's six well-completion services. You gain more, too, by working with this one good source for all six . . . one source that emphasizes service beyond the fee, service above all . . . one source that believes research is its most important service.
HALLIBURTON
OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA
"PROGRESS IN SERVICE THROUGH RESEARCH"